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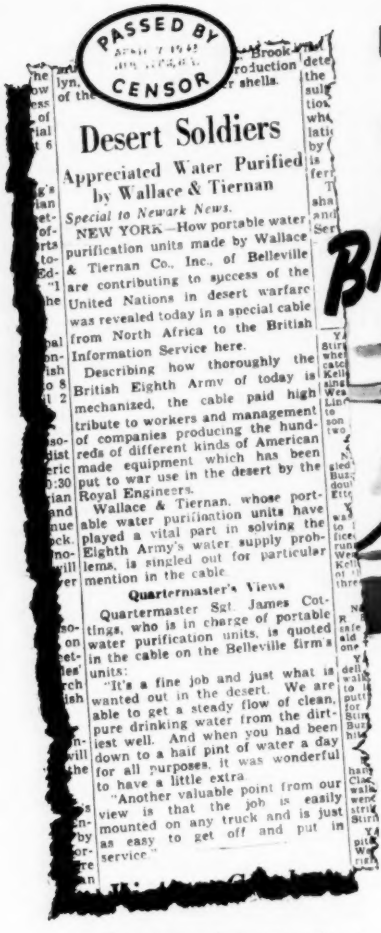

PASSED BY CENSOR

Desert Soldiers

Appreciated Water Purified by Wallace & Tiernan

Special to Newark News.

NEW YORK—How portable water purification units made by Wallace & Tiernan Co., Inc., of Belleville are contributing to success of the United Nations in desert warfare was revealed today in a special cable from North Africa to the British Information Service here.

Describing how thoroughly the British Eighth Army of today is mechanized, the cable paid high tribute to workers and management of companies producing the hundreds of different kinds of American made equipment which has been put to war use in the desert by the Royal Engineers.

Wallace & Tiernan, whose portable water purification units have played a vital part in solving the Eighth Army's water supply problems, is singled out for particular mention in the cable.

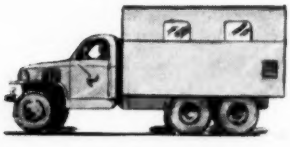
Quartermaster's Views

Quartermaster Sgt. James Cottings, who is in charge of portable water purification units, is quoted in the cable on the Belleville firm's units:

"It's a fine job and just what is wanted out in the desert. We are able to get a steady flow of clean, pure drinking water from the dirtiest well. And when you had been down to a half pint of water a day for all purposes, it was wonderful to have a little extra.

"Another valuable point from our view is that the job is easily mounted on any truck and is just as easy to get off and put in service."

— From Newark Evening News, April 7, 1943



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SAMUEL B. MORRIS, PRESIDENT, 1943–44

JOURNAL
OF THE
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Fundamentals of a University Hydraulics Education

By Samuel B. Morris

BEFORE a group of water works men the need of fundamental training in hydraulics needs no special plea, but it has not always been so. The ancient irrigation works of Egypt and Mesopotamia were constructed thousands of years before the Christian era by rulers who knew nothing of the modern science of hydraulics. They knew that water ran downhill and that a large ditch carried more water than a small ditch. In fact, experience taught them a great deal about slopes and gradients that would carry the water without erosion or deposition of silt.

The great Roman aqueducts were constructed over a period of centuries before and after the birth of Christ. These generally followed contours but also crossed valleys and ravines on high masonry viaducts and pierced ridges by short tunnels. The use of pressure pipes was also known, but the clay pipes carried little pressure and the lead pipes little volume of water.

Thus we see that it was possible to build great hydraulic works thousands of years ago—long before man began to inquire into the laws of nature and, thereby, to become the master of its materials and forces. In fact, we still find ample evidence that hydraulic and other engineering works were constructed without fully understanding or making the most economic use of the materials and forces of nature which we have come now to define as the special province of the professional engineer. Nor do we yet fully understand all hydraulic behavior. There is still ample purpose of research in hydraulics.

It was not until the Seventeenth Century that Galileo in his *Dialogues on Maximum Systems* developed laws of falling bodies; that Huygens, based on experiments, first announced resistance to motion in a fluid as proportional to the square of the velocity; and that Newton, in his great work on the *Mathematical Principles of Natural*

A paper presented on June 16, 1943, at the Cleveland Conference by Samuel B. Morris, Dean, School of Engineering, Stanford Univ., Calif.

Philosophy, dedicated the whole of the second "book" to the study of actual fluids, such as water, air, oil and mercury, as well as certain other ideal fluids—a treatise that we would now call "hydraulics" or that others would argue should be called "fluid mechanics."

In spite of Newton's early contributions to hydraulics, however, his contributions to mechanics and his invention and development of the then new field of mathematics to be known as the calculus have been of far greater value to our present knowledge of hydraulics than his direct researches and writings in the field.

Broad *vs.* Specialized Training

This raises the point to which the greatest emphasis should be given in the fundamentals of a university hydraulics education—that proper training in hydraulics is but a part of a broader university education which must include a fundamental foundation in mathematics, in many fields of science and in what academicians term "separate disciplines." Thus, the study of hydraulics should be considered as a part of engineering education.

Among engineering educators there has been much discussion and argument between those who insist that the engineering curricula should not extend over more than four years and should be devoted exclusively to the study of mathematics, physical sciences, technology and just a little English and, on the other side, those who urge a much broader training in the humanities, language and literature, science and economics, as well as the needed technology, and, if necessary, that the period of training, at least for the more capable students who should advance farther, might run into one, two or even three graduate years. It is only fair to state that those who favor an all-technical four-year undergraduate training believe that their graduates will, by outside reading, later acquire the breadth of training necessarily pushed aside during their undergraduate years.

The author is a believer in the principle of broader undergraduate training, including a broad training in engineering fundamentals. As a civil engineer, he is tremendously shocked by the narrow training offered by the civil engineering departments of excellent reputations in some of the large universities, civil engineering courses without any required geology, thermodynamics, electricity and metallurgy. Practically all civil engineering courses require surveying, highways, transportation, mechanics, strength of materials, structures, hydraulics, water supply, sanitation and, of course, mathematics through differential and integral calculus. So, for a moment, the author would like to speak for the inclusion of those frequently omitted courses which he regards as fundamental in the training of the civil and hydraulic engineer.

Knowledge of geology is very fundamental to much of the work of the hydraulic engineer, e.g. for the location, design and construction of dams, aqueducts, tunnels and other important structures and engineering works. The development and production of ground water, problems of erosion and sedimentation require knowledge of geology and geologic processes. It is not infrequent that the hydraulic engineer must have some knowledge of seismology and of methods and interpretation of geophysical exploration.

Without the knowledge of thermodynamics an engineer can hardly be

said to be adequately trained in any field. Problems of heat and power are encountered whatever his path—heating, ventilation and air-conditioning are involved in a wide range of civil engineering design and construction.

Mention of electricity brings immediately to the attention of all of us the great hydroelectric installations which now produce one third of all the public utility power. Some knowledge of electricity is involved in almost every engineering problem, certainly in the design and construction of all important hydraulic engineering works. And the day is not far off when all of us in the hydraulics field will need to know a great deal in the field of electronics, radio and ultra high frequency techniques.

The entire art of warfare has been revolutionized by these latter electronic developments. The output of such electronic equipment for war purposes has been multiplied many-fold over prewar peace times. After the war, industry is going to find new markets for these facilities of electronic manufacture and, in combination with the hundreds of thousands of men trained in the use and maintenance of this equipment, we can be well assured of new developments which will affect all engineering design, control equipment and manufacturing and inspection methods. In fact the new products in frequency modulation and television will affect the lives of all of us.

Again, what would the hydraulic engineer do with all of his understanding of hydrostatics, hydrodynamics and fluid flow if he did not have in mind the progress of knowledge of metals and metallurgy in the design of pipes, penstocks, valves, pumps, turbines, corrosion- and erosion-resistant materials—if he were not familiar with the high-temperature and at the same time high-strength steels that have made possible a kilowatt of electric power from less than a pound of coal—if he were not aware of the possibility of gas turbines as a reasonable development of the Moss turbo supercharger. It is reasonable to believe that if it were not for the progress in metallurgy, hydraulic engineering would not have progressed so very far beyond the methods used in building aqueducts to supply ancient Rome.

Required Hydraulics Study

What has been said of the need for study of the fundamentals of other fields of engineering in the course requirements of the hydraulic engineer holds true equally in the need of knowledge of hydraulics or of fluid mechanics in the curricula for all engineering students. Fortunately most engineering colleges do require the study of hydraulics by all of their engineering students. There are, however, a number of colleges that do not require electrical engineers, and in some cases chemical engineers, to study hydraulics. But if an engineer is to know the laws of the materials and forces of nature and apply these laws economically in the service of mankind, he must include hydraulics or fluid mechanics in his tool-kit of knowledge.

Hydraulics has always been a basic subject for the civil engineer and, in many schools, is a subject taught by the faculty of the civil engineering department. In recent years, however, the importance to the mechanical engineer of thorough schooling in hydraulics has led many engineering colleges to provide for the administration of hydraulics, hydraulics laboratory and research in their departments of mechanical engineering. This situation

has been strengthened by the very excellent papers presented in the fluid mechanics division of the American Society of Mechanical Engineers which actually preceded the organization of the hydraulics division of the very much older American Society of Civil Engineers.

Nor do the departments of civil or mechanical engineering always contain supervision of hydraulics. In a number of engineering colleges the fundamental nature of hydraulics as a foundation subject for all or many fields of engineering study has led to its being placed in a department of mechanics or a department of mathematics and mechanics. In general, civil engineering departments have been inclined to give their instruction under the good old fashioned name of hydraulics. Many of the mechanical engineering departments have changed to the newer, broader (at least of terminology) concept of fluid mechanics. The emphasis of all of the departments of mechanics or mathematics and mechanics is on fluid mechanics.

There is little doubt that the newer demands of aeronautical engineering have brought about more thorough study of fluid mechanics as a foundation for aerodynamics than existed in the old civil engineering hydraulics laboratory. And these requirements for a more rigorous study of fluid mechanics have brought about the need for aeronautical engineers generally, especially those working in the field of aerodynamics, to have a more thorough working knowledge of mathematics. Even the power of differential and partial differential equations has not been sufficient—the aerodynamist should be familiar with Fourier series, Bessel functions and the transformation of results derived for relatively simple forms of boundary between solid and fluid to others much more complex in their geometrical character through the wizardry of geometrical relations through conformal transformation.

In the past five or six years there has been a flood of new texts on fluid mechanics and the authors of many old hydraulics texts have been forced to include some mechanics of other fluids than water, particularly of air and gases in their writings. These texts may be classified into those that have gone all-out for fluid mechanics, those that have stuck by hydraulics and those that have attempted to straddle the two concepts.

First Course in Hydraulics

Personally, the author is a strong believer in laying a good foundation in mathematics, at least through differential equations, and dynamics before beginning the study of a first course in hydraulics. Preferably, he should favor this first course being of such fundamental character that the expanding needs of the hydraulic civil engineer, the hydraulic mechanical engineer, the aeronautical engineer and the chemical engineer may be built upon the first course in hydraulics. It should include the flow of air and gases, but should not be made so long and complex that all students of engineering should not be required to take it.

The primary requirement for such a first course in hydraulics is that it should be accompanied by laboratory experiments actually performed by the student, with computations based upon his observed data. The course should include:

1. Hydrostatics of fluids and gases: buoyancy; stability of boats, dredges and dams

2. Kinematics of fluid flow, unsteady flow and water hammer

3. Concept of the perfect incompressible frictionless fluid, with development of the Bernoulli equation with its applications to the Venturi principle, weirs, spillways and orifices and the momentum equations

4. Real fluid flow, fluid friction, viscosity, laminar flow, water percolating in granular media, turbulent flow, kinematic viscosity, Reynolds number, determination of critical flow; the application of the momentum equations to pipe bends, hydraulic jump and surge waves; flow in open channels, flow of gases. (Fluid flow in compound pipes and branching pipes should also be understood.)

The student should learn something of the principles of hydraulic similitude, dimensional analysis and the use of models, but he should not be expected to go very far in these fields in a first course. He should also understand the overall principle of the centrifugal pump and the hydraulic turbine, but, here again, he will not have time to make a thorough study of the field without an additional course.

The amount of further study of hydraulics beyond the first course must depend upon a student's main interest, capacity and purpose, and will vary, depending upon the major fields of civil, mechanical, aeronautical and chemical engineering.

The civil hydraulic engineer should learn more of the use of models. He should include hydrology, water supply and distribution, ground water, water purification, sewerage and sewage disposal if he plans to enter the water works field.

No statement of the study of hydraulics would be adequate without mention of the vision and leadership of John R. Freeman in his most effective work in strengthening hydraulics laboratory practice in the United States. Following a European tour in 1924, Mr. Freeman fathered the publication in 1926 of *Die Wassenbaulaboratorien Europas,* published by Verein Deutcher Ingenieure. This volume was translated into English and published with "Description of Other European and American Laboratories and Notes on the Theory of Experiments With Models" under the general title of *Hydraulics Laboratory Practice.*

In addition to these publications made possible by Mr. Freeman, he aided in the establishment of the National Hydraulics Laboratory at Washington and established a permanent endowment under which young engineers selected by the American Society of Civil Engineers, the American Society of Mechanical Engineers and the Boston Society of Engineers are sent to Europe or America for one year for study in the hydraulics laboratories.

Mr. Freeman's vision and initiative have brought rich reward. Throughout the United States, Freeman Scholars are heading university and other hydraulic research laboratories. The Corps of Engineers, TVA, the Bureau of Reclamation, the Aluminum Company of America and countless others are making hydraulic model studies of all major river works. In fact, the effect of various stages of construction is studied and forecast by means of model study. Practically all of this progress has taken place in two decades as a direct result of Mr. Freeman's foresight and devotion. Thus has the work of a great hydraulic engineer enriched the knowledge and experience of his successors.

SERVE BY SAVING

At midyear in 1942, the water works man could properly set his mind and action about the slogan "Save, Stretch and Share." A year later, with the armies in the field requiring the utmost support from those who remain civilians, we must **Serve by Saving.**

Save what? Above all else—manpower and materials. Water works executives, even though they direct the affairs of an essential industry, must leave no method unexamined which might make possible the use of less manpower. All the rules and bulletins that have been issued do not set aside the simple fact that today's work must be done by men—and women—who work harder than they did in peacetime.

Now—for a vital matter: What have you, in your department or company, done to carry on more work with fewer workers? Will you write the A.W.W.A. headquarters office **today** and state simply and briefly what you have done? Whether it has been in the production or pumping of the supply, in your service or metering activities, in your meter reading or office work, in your use of transportation—whatever it might have been—tell what you have done. The next issue of this JOURNAL, with **your** help, will bring to every reader as concise a summary of the information as can be developed. This is planned in order to help water works men meet tomorrow's manpower problems, for **they**, along with all other good Americans, must find ways to save manpower.

Along with manpower saving goes material saving. Read the Cleveland speeches by Krug and Gorman, immediately following. Krug's sentence—"You and your customers will be giving the war effort a mighty boost if you can keep your requests for critical materials to a minimum."—is not "foolishment" but fact. Along with it, however, note his later sentence—"I want to make clear the distinction between maintenance and expansion because we are anxious for you to **practice the former and discourage the latter.**"

Do you realize that the reporting water works, as a group, for the past eighteen months have not consumed the amount of maintenance and repair materials that the War Production Board has authorized them to use? Not only have they stopped their construction and minor extensions in many instances, but they have cut down their maintenance. This practice of under-maintenance is dangerous. It endangers service on the one hand and on the other makes more likely the emergency need for new equipment.

So—strike a balance! Maintain the old to save the new and you save materials—or rather you send more bombs to Berlin and Tokio.

For the Midyear 1943 – SERVE BY SAVING

Plans and Policies of the Office of War Utilities

By J. A. Krug

I AM glad to meet with you again to talk over our joint problems and to see what we can do to discharge more efficiently our mutual responsibility—that of furnishing an adequate supply of water for the arsenal of war the United States has become. That responsibility is a tremendous one and a growing one. Few persons outside this room realize the voracious appetite for water possessed by our war production machine; and the general public realizes it not at all. It is a tribute to you gentlemen that the public takes its water for granted. You have given the people such excellent service for so many years that they are unaware there are any complex problems in providing it. I hope you will be able to keep on doing that. The job will tax your ingenuity and your resourcefulness as the demands of war increase. You will be called upon to do more and more—and you will have fewer materials and fewer men to do with. The high order of capability displayed so far by the water industry is the best guarantee I know that you will find a way to carry on for the duration.

It's always a safe rule never to talk to experts about their own subject unless you are an expert yourself, and it's a rule I am going to follow. So instead of trying to tell you things you already know—and know better than I do—about water supply problems, I am going to talk to you today about some of the problems facing the War Production Board and the Office of War Utilities and how you can help us solve them.

WPB and Water Supply

Let me begin by emphasizing to you the fact that the War Production Board is exactly what its name implies, and nothing more. It is made up of men of every political creed and every shade of opinion. I say that because sometimes the WPB's motives are misunderstood. Actually, it has only one motive and that is war production. As a part of its job of war production, the board has also the responsibility of protecting essential civilian services, so that war production can be carried out. In the fields of water, gas, power and communications, the Office of War Utilities has that same function. Narrowing that general policy statement to water alone, it is our job to see that an adequate supply of water is provided for war production and essential civilian services—*with the least possible expenditure of critical materials.*

I want to emphasize that last point to you—"the least possible expenditure

An address presented on June 16, 1943, at the Cleveland Conference by J. A. Krug, Director, Office of War Utilities, Program Vice-Chairman, War Production Board, Washington, D.C.

of critical materials." I am sure you would face no very serious difficulties in providing all the water necessary to meet these newly increased demands if pipe and pumps and valves and the thousand and one other items you need were readily available. But these things are not readily available and they are not going to be for the duration. That may sound as if we expected you to perform miracles. *We do.* We expect you to operate to the last possible moment with your present equipment and then figure out a way to get by with a minimum of new equipment. Every day you can manage without dipping into our national supply of critical materials, those materials can be used to forge the weapons that are beating the Axis.

Materials Shortages

We can all remember when we considered our national resources of materials like steel and copper and aluminum were practically limitless. We would have hooted—and as a matter of fact we did hoot—at anyone who tried to tell us that we ever would be short of basic materials. What we did not realize was the almost limitless capacity of our great country to manufacture and fabricate these materials. Now we have reached a rate of manufacture such as the world has never seen and never expected to see. Since the month before Pearl Harbor, the United States has increased its monthly output of munitions more than fivefold. In March of this year we produced three times the volume of airplanes that we did in March a year ago, and bigger, faster, heavier planes too. In March 1943, we turned out over three times as much artillery as we did a year earlier and we are sending ships down the ways at two and a half times last year's world record. Raw materials producers have not been idle in the meantime. We have increased steel output by a third. The United States this year will have more copper at its disposal than the entire world production in 1939. Aluminum production has been multiplied and re-multiplied. Nevertheless, there is a ceiling upon the amounts of these materials we can produce—*and there is no ceiling upon the demands of modern war.*

I can best illustrate this point by telling you about the demands for steel for the third quarter of 1943. As you know, we have just completed the allocations for the third quarter. The direct war demands—and remember that all normal civilian items like automobiles, refrigerators and washing machines are not being made—the direct war demands of the Army, the Navy, the Maritime Commission, plus the indirect military and basic civilian demands of the railroads, the utilities and so forth, were one-third greater than the total anticipated steel supply. That means that these essential programs must be reduced one-third on the overall in terms of reported requirements. If ever any of you get the feeling that the Office of War Utilities is being unduly harsh in its treatment of your requests for materials, just remember that. Every pound of steel you can save means a pound of destruction that can be delivered to the Axis. Every month you can delay a request for steel means you have brought the end of the war just that much closer. We are well aware that there are some materials you must have, some improvements that must be made and we intend to see that you get them. But we do urge you to ask yourselves about each item: "Where will this do the most good—in the city water system or delivered to Tokyo by air express?"

Conservation Possibilities

As a result of the materials situation, I am going to ask you to cooperate with us and with the other utilities in holding water demands to a minimum. We all know there is a great deal of construction tied up in meeting that small percentage of increase imposed by the peak demand. In most communities in the United States, peak demand has increased as a result of war activity, and all of you feel the need to increase your systems to meet it. That is a normal desire and one that ordinarily would be met without question. At this time, however, when direct military demands for critical materials are so urgent, we just do not have the necessary materials for extensions of plant capacity to meet peak demand and nothing else.

I am asking you, therefore, to take whatever steps necessary through the means available to you to reduce your peak loads. Generally, a request to the public to refrain from using water for any but necessary purposes in the hottest, driest weather will get the job done. I am not trying to tell you how to accomplish this result, but I do want to impress upon you the vital necessity for doing it.

This is not an added burden we are attempting to impose upon water systems alone, but a course of action that is being adopted by gas, power and communications utilities generally. I am sure you all have seen the extensive advertising campaign carried on by the telephone companies to reduce their peak load. The gas companies of the country carried on an effective program last winter and are planning an expanded campaign this winter. I met with a group of leaders of the electric industry in Washington recently to discuss a similar campaign for power use. Mr. Gorman and I and the other officials of the Office of War Utilities are not proposing these measures to you and to the other utilities idly and without serious consideration. In fact, the opposite is true. We have hesitated to ask you to adopt drastic conservation measures, even after we thought they would be necessary, because we wanted to be absolutely certain of the necessity for them. There can no longer be any doubt. The criticalness of the materials situation is increasing as the war effort gets into full stride. If we are to forge the weapons that will beat the Axis, we are going to have to practice strict conservation on the home front. Many of you have halted the unnecessary consumption of water in our communities in time of drought and you know the steps that have to be taken. Fortunately, we have no drought of water, but we do have a drought of materials. We are hopeful that there will be set up shortly in every city in the United States a joint effort of all utilities to persuade their customers to practice conservation. Let me urge you to take a full part in that activity. Please do not wait for that, however, but start telling your customers now that conservation of water is necessary.

I would like to return for a moment to the gas industry and its activities of last winter because it is a good illustration of the type of conservation campaign I am asking you to undertake. Like water, both natural and manufactured gas can be delivered to meet the demands of all customers 90 per cent of the time. It is only during the extremely cold weather that there is any question of a shortage of gas. The gas systems did not have sufficient capacity to meet all peak demands last winter because materials for expansion could not be granted. The gas systems in all

the shortage areas instituted an extensive publicity campaign to reduce peak demand and these campaigns were very successful. We learned from that experience that the public is willing to practice reasonable conservation if they are asked to do so and if the reasons for it are fully explained to them. You and your customers will be giving the war effort a mighty boost if you can keep your requests for critical materials to a minimum.

Let me qualify that last statement slightly. What we are attempting to hold down is the use of critical materials. Major water system expansions require large amounts of such materials. We realize, of course, that present systems must be kept in sound operating condition to meet the increasing demands of war and to continue to operate over capacity, as many of them are doing now. As an earnest of that realization, we recently have increased the preference rating for water utilities for maintenance, repair and operating supplies to AA–1, a top military rating shared by few industries. I want to make clear the distinction between maintenance and expansion, because we are anxious for you to practice the former and discourage the latter.

Need for Co-operation

One of the best ways you can help meet the war load is by a more liberal policy toward neighboring systems—particularly toward those smaller systems on the outskirts of the larger cities which have been heavily burdened by new war plants and war housing. Many of these small systems have been taxed far beyond capacity. It would take vast amounts of critical materials to enable them to meet these added burdens by themselves. Some of you, however, can help us help them by being good neighbors. If you will keep that in mind you will be helping to arm our soldiers and sailors on the fighting fronts just as surely as if you made the weapons yourselves.

I want to give you a word of warning about the good news we have been hearing from Europe these past few days. I am just as hopeful as you are that we never will hear any bad news, but I caution you against the tendency to regard this war as all but over. I would like to believe that, too, but the judgment of experts tells us that we are in for a long, hard war. If it ends sooner than we expect, so much the better. Surely, however, we must prepare for several years of war. We must plan carefully for greater difficulties that may lie before us. I am going to ask you, therefore, for a major job of planning so that we may be prepared for any eventuality.

We have been coasting along for the last two years with a plentiful supply of water. Let us hope we continue to have plenty of rainfall for the duration. Let us hope that, but not depend on it. A drought next summer would not lessen the demands of war production on our water supply and a protracted drought condition undoubtedly would cause us serious difficulties. What would be your situation in case of drought? Where would you have to turn for water in case your present supply was exhausted by drought? What materials would be necessary, and when, to afford your system reasonable protection against an interruption of service for war production and for essential civilian use?

Those are the things the Office of War Utilities needs to know. I am asking you, therefore, to make an immediate appraisal of your current and

potential war load, of the situation you would be called upon to meet under drought conditions and to submit to us at the earliest possible date a complete statement on these matters. We are trying to look ahead, to see what we may be called upon to provide in the way of materials under changed circumstances and what we can do toward providing them. This is a matter of utmost importance and I ask that you give it your attention.

There are a great many other things I would like to talk to you about, but conservation of materials is so uppermost in my mind these days that it is difficult for me to discuss anything else. Gentlemen, we must make the most of our materials if we are going to make this a reasonably short war. We can do it and with your help we will do it. Perhaps an explanation of the essentiality of water for war production will help make your customers realize the necessity for conserving it. If the Office of War Utilities can help you in planning a campaign along the lines I have indicated, we will be very happy to do so. Rest assured you will have the full force of the government in back of your efforts. This is a time when civilians must save, so American boys may live. The side in this war that has the most and best weapons not only is the side that wins, and wins in the shortest possible time, it is also the one that has the least casualties. A ton of steel that you *don't* use may save the life of an American soldier. And that's worth doing.

Administrative Policies of the Water Division—Office of War Utilities

By Arthur E. Gorman

IN the paper immediately preceding, Mr. Krug has presented a program by which water utilities can do their part to meet the extraordinary but essential loads that our nation must carry to win this war. He has also emphasized the need of meeting these war responsibilities with a minimum use of the materials required to serve the armed forces. I shall discuss, from the viewpoint of the Office of War Utilities, some of the administrative aspects of carrying out these policies, not only in meeting the great responsibilities now being carried by water utilities, but also the heavier ones to come as the production load in this all-out war accelerates.

At the Chicago Conference of the A.W.W.A. last June, Mr. Krug emphasized the growing importance of water supply in war production and announced his intention of creating a Water Section in the Power Branch, of which he was then chief. In August 1942, the new section was organized. It has worked in close harmony with the Association and representatives of the water industry. President Abel Wolman rendered timely and valuable assistance in organizing this section and has continued to serve as special consultant. Secretary Harry Jordan has been a real friend and helpful counselor. We have also been assisted by the Association's special committees and by those of the Water and Sewage Works Manufacturers Association.

Under a WPB Order of September 2, 1942, jurisdiction within the board for water supply other than for irrigation was vested in the Power Branch. Administrative responsibility has been in the new Water Section. In February 1943, when the Office of War Utilities was created, five major divisions were organized, each representing one of the following utilities: power, manufactured gas, natural gas, water and communications.

As one of the seventeen claimant agencies sharing in the nation's war output of materials and equipment, the Office of War Utilities has the responsibility of recommending the amount that should be allotted to utilities and of ascertaining that the utilities for whom this material and equipment is obtained carry their full and respective share of the nation's war load. This calls for a high degree of co-operation with the many utilities and for a system for equitable distribution of available materials.

An address presented on June 16, 1943, at the Cleveland Conference by Arthur E. Gorman, Director, Water Division, Office of War Utilities, War Production Board, Washington, D.C.

Mr. Krug in his joint capacity as Director of the Office of War Utilities and Program Vice-Chairman of WPB has recently put into effect many policies and administrative procedures which shorten the time required to process the utility project applications and work approval under various limitation orders. Before discussing the specific administrative instruments through which priority assistance is being given to the 13,500 water utilities of the nation, and particularly to the 500 or more which are carrying the greatest proportion of the nation's war effort, however, I should like to review briefly the general relationship of the water utility to the War Production Board.

War Demands on Water Supply

This war more than any other is focusing attention on the importance of water as a prime war resource and on water utilities as essential factors in war production. The selection of water works as prime targets for destruction is ample testimony of the importance attached by military men to water service in modern warfare. The surrender of Hong Kong, Casablanca and Pantelleria and other supposed "strong points" was accelerated by cutting of water supplies.

After this second world war started and long before Pearl Harbor, our utility systems began to feel the effect of the accelerated war production through additional demands for service. Since Pearl Harbor, these demands have exceeded any prior predictions and have placed unprecedented strain on many water utilities. They had no organized pattern to follow, but somehow managed to meet demand after demand in a very difficult period when competition for materials was sharp.

Those hectic demands of war construction showed what the water utilities could and could not stand in the way of sudden expansion. The struggle to meet these abnormal demands brought forth a brand of loyalty and resourcefulness within the water industry of which we can all be proud.

In many water systems, the demands for service to army camps, naval bases, ordnance works, industry and housing have put even the most optimistic long-term construction plans into complete eclipse. In most war-affected areas, substantial additions to plant and distribution systems had to be made. In several places, entirely new sources of supply had to be developed to meet the excessive war loads, for instance at Newport News, Va., Mill Creek Valley, Ohio, Houston, Tex., and Wilmington, N.C.

We are now entering the phase of the war program when full emphasis is on production. This production is highly integrated and must be maintained to schedule; yet it must be kept flexible enough to meet the demands of the war strategist as our fortunes in combat affect the need of various war supplies and equipment.

The recent decline in war construction has not been followed by a relaxation in demands on water utilities. They are still on the upgrade. The operation of new plants calls for additional water supply for production purposes and still more for general domestic use in the areas where employees reside or where additional Army and Navy personnel are housed.

A recent compilation of existing water supply deficiencies in critical war areas as reported by state sanitary engineers has revealed some very interesting facts concerning deficiencies in public water systems. The percentage

distribution of these deficiencies by major water works facilities are: supply, 38.5; pumping, 14.4; treatment, 19.7; and distribution and storage, 27.4.

There is certainly no room for complacency. A real war job lies ahead of us. It is expected that war production this summer and fall will begin to approach the forecasts for top war demands. We have yet to learn to what extent our water utilities can maintain continuity of service when the new production load continues at capacity or accelerates as new war needs develop.

Adequacy of Supply

The importance of rainfall to water supply and demand is familiar to all of us. Since the war began, rainfall conditions in most sections of the country have been unusually favorable for maintaining adequacy of water supply. According to U.S. Weather Bureau Statistics, rainfall for the United States has been above normal for the last three calendar years, being: 104 per cent of normal in 1940; 112 per cent in 1941; and 107 per cent in 1942. To May 1, 1943, rainfall was normal in the northeast, above normal in the north and northwest, about 80 per cent normal in the Mississippi Valley and plains area and relatively low in New Mexico and Arizona.

Reservoirs are spilling in most areas; stream flows have been high generally, with some flooding; perennial underground supplies in sand and gravel deposits are well filled; and conditions have been favorable for recharge to the deeper aquifers. These are all favorable conditions, but even so we have some very serious underground water problems. The concentration of war industries in areas where ground-water elevations for many years have been receding at an alarming rate has developed some serious local situations.

It is too much to expect that rainfall and weather conditions will continue to be favorable should the scheduled war production load continue for the next two or three years. We must face the possibility of extended periods of drought locally or over wide areas. We must appraise our systems both as to supply and service and determine where our weaknesses are or where they may develop.

Within the next few weeks, many utility operators in this country will be requested to submit to the Office of War Utilities a report of deficiencies in their systems which would result from extended drought conditions and an estimate of materials which would be required to supplement existing plant in order to maintain service. As Mr. Krug has mentioned, the need of this information is urgent because it is essential that we prepare for any emergency scheduling of material and equipment which may be necessary. It will be appreciated if you will give this appraisal the immediate attention of yourself and your associates.

Maintenance of Service

The greater emphasis being placed on production of equipment and supplies for aerial and amphibious warfare and shipping is calling for increased production of steel, copper, aluminum, aviation gasoline and rubber. Plants manufacturing these products use very large quantities of water and, in many instances, the water must have special chemical and physical properties to be suitable.

In the various processes followed in the manufacture of one ton of ingot

steel, 75 to 80 tons of water are used; before this steel is made into fabricated products, about 175 tons of water are used. In the production of a gallon of gasoline, from 7 to 10 gal. of water are used in various processes of manufacture. One of the largest alcohol producing plants uses about 100 gal. of water for each gallon of alcohol produced. Before an airplane engine is approved for installation and long distance flights, from 125,000 to 150,000 gal. of water are used in testing it. The great windowless "blackout" plants built for war production depend on water for operation of their essential air-conditioning equipment.

The nation's war production program is highly complex. Parts for a plane, a tank, a gun or a ship are made in numerous plants in cities and villages all over the nation. Water service is essential at all of these plants if production is to be maintained. It is essential to community life in the areas within which the plants are located as well as to the individual well-being of war workers and their families. Where water service to housing is inadequate, labor turnover is high, which, in turn, lowers plant efficiency and productive capacity. Water utilities have a tremendous responsibility to this nation to maintain service during this war emergency, however long it may last.

The Office of War Utilities is prepared to help utilities obtain the necessary materials and equipment to meet this responsibility whether it be for maintenance of existing plant or new facilities required as a result of war loads which cannot otherwise be met. It is obvious that in such a tight materials and manpower market, all projects must be screened and only the essential ones given material allotments. A certain amount of procedure which I called "red tape" before I came to Washington is necessary to maintain proper controls, but our efforts are being directed to minimize it.

Procurement of Materials

All utility operators will be interested to know that within the past few weeks, some striking changes have been made by the Office of War Utilities in the administrative work pertaining to authorizations under which materials may be obtained for essential operations and new facilities. As things now stand there are three basic forms or documents with which every utility operator should be familiar. These are:

1. WPB Order U–1
2. WPB–2774—Application for Authority to Begin Construction
3. UF–13—Water Utility Report of Quarterly Deliveries, Withdrawals and Inventory of Materials.

The U–1 order is the Office of War Utilities substitute for the P–46 order of the former Power Branch. To many of you it is an old friend. It has been and is still going through a series of legal and technical changes, the latest dated order being that of May 31, 1943. Recent panel meetings with representatives of industry resulted in some important recommendations from water utility operators which are being adopted. Perhaps the most important affecting water utilities was that the inventory, withdrawal and delivery base has been changed back to the old P–46 figure of 60 per cent of the 1940 base. This was done in the latest revision. The new U–1 order now being prepared and soon to be promulgated gives recognition to the individuality of the various utilities in their operations.

The primary purpose of the U–1 order is to aid the utilities by extending to them a high AA–1 automatic priority rating by which they may obtain materials to maintain plant and equipment without submitting applications to Washington. In extending this aid, certain limitations are placed on inventory withdrawals and deliveries in various defined classes of equipment and supplies.

Form WPB–2774,* just recently released, is to be used in place of all PD–200 and PD–1A forms, U–1 letters and CMP–4C forms formerly used for projects or project amendments. This new and simplified form has been designed especially for utility projects. It calls only for basic information needed to identify the project, and the amounts and value of critical materials involved which are necessary for statistical purposes. It has been our experience with water project applications that they are so varied in scope that the questionnaire type of application serves neither the applicant nor the analyst to advantage. Therefore, in submitting data in support of projects for which priority assistance is applied on this form, applicants are given the widest possible leeway. An administrative letter now in preparation outlines the type of information needed by our analysts.

To date, only those water utilities serving approximately 50,000 population or higher have been required to report their quarterly inventories to the War Production Board. The report forms used have been UF–13 for dollar value of delivery, withdrawal and inventory and WPB–921 for physical items of certain types of material in excess inventory.

To simplify this work, the Office of War Utilities has eliminated the necessity of filing quarterly the detailed lists of items in excess inventory. In its place, a system for keeping a perpetual excess inventory record has been set up in the offices of the Regional Utilities Inventory Control Engineers. The reporting utilities now need only to advise the regional office of any changes in their excess inventory, such as items used or sold from excess inventory.

It is proposed to simplify and shorten the quarterly report form UF–13. Plans are also being made to require an abbreviated report, possibly on a postcard form, from the medium-sized utilities.

Utility plants must be maintained. The longer the war lasts, the more important a scheduled maintenance program becomes. We cannot risk an epidemic of interruptions in war production next year resulting from lack of maintenance this year. There is no economy in deferring essential maintenance; in fact, the cost in materials and production capacity for replacements may exceed many times that of initial maintenance. It was for this reason that the original P–46 order was issued, authorizing utilities to extend an automatic priority rating for materials needed for essential maintenance, repair and operation.

There are some indications from our records that some utilities in their praiseworthy zeal to co-operate, by using a minimum of critical materials, or because they were discouraged in earlier attempts to obtain supplies under inadequate priority ratings, may now be deferring essential maintenance of plant. They are not making effective use of the provisions of the new U-1 order established specifically to help them better to serve the overall war effort. It is of utmost importance that we strike a sound balance in these

* *See* page 977.

matters. While the Office of War Utilities is seeking to minimize the use of critical materials so that more may be available for direct war purposes, it does not wish to do so at the expense of proper maintenance of essential water works.

Controlled Materials Plan

The Controlled Materials Plan, which was started in a limited way the first quarter of 1943 and will be in full operation effective July 1, is a new development which has improved the method of allocating the three critical materials—steel, copper and aluminum. Water projects, as a rule, are not much concerned with the Controlled Materials Plan administrative details, although each manufacturer is more or less affected. Under this plan, allocations are kept in balance with production capacity so that materials for approved projects may be delivered to meet schedule requirements. It avoids the confusion and disappointments which developed under the priority system, when authorizations for material were in excess of production capacity.

The amount of controlled material allocated to water utilities during the second and third quarters of 1943 is summarized in Table 1.

As Mr. Krug has pointed out, until such time as the materials situation eases up, it will be necessary to continue to limit allotments to new construction projects. The steel and copper situation is very tight. It is proposed to obtain from all utilities the copper which was frozen last October under the M–9–c order. Possibly some of the water utilities may already have received requests by the Copper Recovery Corp. concerning copper tubing on hand. It is destined to move into useful war service in the very near future. Through the controlled and up-to-date records of excess inventories available at the WPB regional offices, much can be done to help utilities in obtaining material and equipment needed. Co-operation between utilities in obtaining needed supplies has never been more essential. Large utilities must continue to help the smaller ones, both in materials and equipment and in the provision of standby emergency service.

TABLE 1

Allocations of Controlled Materials

Quarter 1943	Material	For New Construction	For Maintenance, Repair & Operation	Total
Second	Steel	12,975 tons	5,900 tons	18,875 tons
Third	Steel	4,500 tons	6,060 tons	10,560 tons
Second	Copper	40,300 lb.	108,000 lb.	148,300 lb.
Third	Copper	19,500 lb.	120,000 lb.	139,500 lb.

A recent survey has indicated that many water utilities are still holding, in plant, material and equipment they may never use—material which if released to other utilities would help substantially to expedite important projects now being delayed because of inability to get deliveries on critical items. A few cities have already voluntarily listed such plant equipment with the Office of War Utilities for sale to help meet the current shortage in special types of equipment.

In reviewing project applications from water utilities, it is clearly evident that much material and equipment is being requested to meet actual or forecasted peak-hour loadings. There is no desire on the part of the Office of War Utilities, so long as supply is available, to limit any legitimate uses of water for domestic, industrial, irrigation or fire protection purposes. None of us wants to see limitations put on the uses of water which are so essential to our high American standard of living, but it is possible that, under prolonged drought conditions, drastic action to conserve water may be necessary. There is substantial evidence that many applications for new equipment and service could be deferred and the need of them offset by a well organized consumer conservation program. The fine water conservation program carried out in Philadelphia during the summer of 1942 and being continued this summer is an example of how a 15 to 20 per cent cut-back in peak demands may be effected. A well planned water conservation program could in most cities more than offset the effect of the increased loads caused by victory gardens.

Program for Co-operation

The outlook ahead is favorable, but potentially serious. The Water Division of the Office of War Utilities will make every possible effort to help utilities meet their war loads. Many more basic data are needed before the true facts as to our essential war requirements can be established and materials provided to meet them. This is especially true if water utilities must operate under drought conditions. Never before has close co-operation between government, utility operators and consumers been more needed.

Some of the ways by which such a co-operative program may be advanced are:

1. Maintain plant in good operating conditions at all times. Use the U-1 order as fully as necessary for this purpose.
2. Defer major extensions and betterments of plant as long as possible by developing a consumer conservation program to reduce waste and lessen peak loads.
3. Appraise plant for effective services to essential consumers for the duration of the war: (a) under normal rainfall conditions; (b) under drought conditions.
4. Report to the Office of War Utilities an estimate of materials and equipment needed to maintain effective service under these two conditions, together with a schedule of delivery dates.
5. Co-operate with neighboring utilities in pooling of water supply resources, where practicable, through use of inter-connections.
6. Co-operate with the WPB Regional Utilities Inventory Control Engineers in the use and exchange of materials and equipment in excess inventory.
7. Report for sale any material and equipment in plant not now reported as excess inventory which is not likely to be used.
8. Look to the Office of War Utilities for advice and assistance in connection with all water supply problems involving war production.

Relation of Public Water Supply to the Postwar Program

By Willard Chevalier and Abel Wolman

The Impact of Postwar Planning on Public Works Programs—Willard Chevalier

BY prearrangement, Dr. Wolman and I have divided the subject of this evening's discussion. I am going to talk about the general impact of postwar planning upon public works programs in general, while he will narrow the subject down to the water works field in which you are especially interested.

As I contemplated this subject today, I was reminded that ten years ago this week, this Association assembled in Chicago to discuss the same subject—public works as a factor in the American economy under the circumstances that then prevailed. To me it is rather an interesting fact that now, ten years later, we should be talking about the same subject. I say "interesting" because at that time, ten years ago, we had twelve to fifteen million unemployed in this country. We were trying by every desperate means within our power to raise prices and consumer income. Our great aim was to achieve "reflation," which was a polite name for inflation. We were seeking some device by which to "prime the pump," of the national economy. We wanted and craved a shot in the arm that would put this faltering economy of ours back on its feet. That was the picture ten years ago when we met to talk about the effect of public works on the national economy.

Two Types of Public Works

It was at that time that the American people as a whole really made their acquaintance with the public works program as a device to throw the weight of government into the economic cycle by means of deficit spending on a large scale. The effort was made at that time for two reasons, reasons that not only were different, but also were at times rather conflicting.

The first of these reasons was to create jobs in any possible way, any kind of jobs—boondoggling, work relief, public works. It made no difference so long as we could get the unemployed on the public payroll. Those who were advocating a public works program for that reason looked upon the public works program as a relief measure. Its objective was social. Its ultimate instrument turned out to be, after a number of changes, the WPA.

Then we had another group that was very much concerned with the place of

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public works as a means of stabilizing or restoring the economy. The members of this group looked upon it as a device for priming the economic pump. They favored a large program of necessary and useful public works financed largely by federal borrowing that would help make up for the lack of private investment and thereby stimulate a dormant economy. These people looked upon the public works program as device for recovery. Their objective was economic. The ultimate instrument to carry out that program was the PWA.

That was the picture ten years ago—a public works program for the purpose of creating jobs on the one hand and one for stimulating a dormant economy on the other.

The Present Situation

Today, we are witnessing the greatest manpower-absorbing and pump-priming undertaking in the history of the world. If you look upon our war spending as a species of public works program, you must agree that it beggars the most fantastic aspirations of those who complained in the Thirties that our public works program was not more successful only because there wasn't enough of it. Today, we are desperately short of manpower. Today, we have to put ceilings on our wages and prices—at least, we are trying desperately to do that. Our pump is primed to overflowing, so far as public spending and deficit financing can contribute to that end.

We are trying now to siphon off, by means of taxes and enforced savings and whatnot, this surplus purchasing power that is abroad in the community. In other words, we are doped to the eyes with inflation and the economic doctors are trying to get us to quiet down and stay in bed.

This situation is exactly the opposite of what it was ten years ago, but once again we hear of the public works program—the great public works program that will be needed to meet our post-war situation. It all sounds incongruous as I present it, but I submit to you, as very practical men engaged in the administration of a vital phase of our public works activity in this country, that you must face this subject boldly and courageously at this point and that you must take a wise position with respect to it.

I believe it is important for all of you and all of us who are concerned with public works to do this, because the term "public works" is used so freely by a great many people who would use the activity by which you make your living and serve your respective communities as a lever whereby to effect radical changes in the form of our economy and perhaps in the form of our government. And you, it seems to me, the least of all Americans, can afford to have this vital function with which you are entrusted perverted to any purpose that eventually will bring it into discredit with the American people.

A major responsibility of public works men in all branches of service it seems to me, is to prevent confusion in the mind of Joe Doakes on Main Street between legitimate public works and the so-called pyramid building that lies behind the deficit financing theories of those who would like to make America over. This is a serious threat. If we do not face it, if we do not clear up this confusion, the essential and necessary public works activities of this country will suffer.

The Postwar Outlook

Now, then, in order to see the place of public works in the postwar picture, let us take a look at the postwar outlook. When we do that, we find that after this war we shall have a very large deferred demand for goods and services. The American people have been doing *without*—they have been doing without many of the things they have come to look upon as essentials of American living. Then, too, they will have a large accumulated purchasing power. The savings today are enormous. The money now in war bonds will be available. The people have wiped out a very large part of their consumer debts of one kind or another. The result is that there will be available in the hands of the American people a vast purchasing power to buy the goods that they have been denied during the war. And finally, we see an enormous "must" demand for human services the world over to rehabilitate a world that has been treated so destructively by the ravages of war.

The Critical Period

Our paramount task, following this war, will be to bring together, and to bring together as quickly as possible, the ample manpower, the ample demand for goods and the ample purchasing power that will be available. Now I want to emphasize the expression "as quickly as possible" because there, it seems to me, will be the critical phase of the postwar period. I say this because in the months immediately following the war, we shall be up against such inflation dynamite as we cannot possibly know during the war.

Just as soon as the fighting stops, the struggle to keep the lid on the vast accumulated funds in the hands of the people will be tougher than ever. The patriotic appeal will be worn out. We can appeal no longer to the American people to curb their desires and refrain the bag. We shall have a natural tendency to go out and satisfy ourselves with all the things we have been denied from spending their money in order to help win the war. The war will be in and, since we shall have the money to spend, it will be exceedingly difficult to put the curbs upon inflation that we now can maintain in the name of patriotism. The people will want things and they will have the money to buy them. The question is whether they will want them so badly that they will demand the abolition of all controls, crowd into the market place with their money and bid up prices until we have an inflation the like of which would beggar anything we have ever imagined.

During this period, the months immediately following the end of the fighting, we shall be in a race, a race between runaway inflation and the conversion of our industries to produce civilian goods. In my judgment, that race must be won within six months or a year, or else we shall not be able to control the inflationary forces that will be inherent in our economy at that time.

Therefore, the job of America—our industries, our people, our government—the dominant job that will confront us the minute that the fighting stops is to get ahead with the production of the kind of goods that the American people will want to buy, the kind of goods that they have been doing without. We must get in production, just as quickly as possible, to pour those goods out on the market where they can help to sop up the purchasing power that will remain in their hands.

This, in my judgment, will be the critical postwar period—the first six months, the first year perhaps—I don't know whether we can survive a year without accomplishing this objective. That critical period will determine whether or not we shall have a collapse of our entire economy. It will determine whether or not the people will suffer the loss of their savings and of their faith in the future with all that that would mean to the security of your industry and with all that it would mean to the job-making capacity of American industry as a whole. If we can weather that threat, we may well have from five to ten busy years following it, years that may be reasonably prosperous despite the war burdens that we must carry. If we can get through this first six months or a year without collapse, and then have from five to ten reasonably good years we may be able to make up for all these deficiencies in an orderly manner; but if we can't make that first six to twelve months without collapse, we shall be in a bad way indeed.

This period will determine also whether we shall be able to restore American ideas and institutions or whether we shall be forced to adopt some of the very measures that we are fighting in this war. If we are unable within that period to rebuild our industries and to reconvert them to produce the volume of consumer goods that our people will have the money and the desire for, we may have to look forward to an indefinite period of regimentation, regulation and other government controls that none of us wants to face, I am sure. But they may be forced upon us by circumstances. And if we are forced into that position immediately following this war, no man is wise enough to say when we may be able to throw off those shackles and get back to the American conception of a free economy.

Program of Public Works

Very briefly stated, then, it seems to me that the major postwar problem is to swing our manpower as quickly as possible into the task of rebuilding and reconverting our productive facilities to meet the pent-up civilian demands of the people. This will be done only by creating productive jobs, jobs that will add to the actual wealth of the people. That cannot be accomplished by any form of made-work jobs, by any process of simply putting people on payrolls for putting in their time. If we are going to cope with this situation, every job that we create must be a job that will produce something useful and usable, something that the American people want and need and are willing to pay for.

There should not be any reason at all to create artificial purchasing power or to devise synthetic jobs. The situation will be exactly opposite to what it was ten years ago, when we were trying to create purchasing power and when we were trying, by any means, to create jobs.

A proper postwar program, then, calls for both public and private enterprise. It calls for the provision of both public facilities and private facilities. The chief function of government, however, will not be to stimulate a prostrate economy or to supplant private industry in putting our money to work. It will be, on the one hand, to get under way the large backlog of necessary public construction that will have accumulated during the war and, on the other, to create a climate in which private enterprise will be able to go all-out with the perfectly enormous

productive job that it must do if we are to get our civilian economy in balance before it is too late.

Those are the two postwar jobs of government, both of them contributing to the end I have just described of creating useful and usable wealth to meet the needs of the American people, whether it be in the form of worthwhile public works or in the form of creating a climate in which private enterprise can take up the job that will be cut out for it. Nothing else can assure a maintenance of the earning power of our people and of our business concerns. And be it noted here that the earning power of our people and of our business concerns is what we shall need to pay the taxes that will be required to finance not only our essential public works, but also the heritage of debt that will be left to us by the war.

Utility as a Basis of Projects

Here is not the place to discuss in detail what should be done to create that climate. That is a matter for our economists, business men and government officials to discuss, describe, define and legislate. That task is in hand in many quarters today through competent agencies. I want to turn directly to the public works phase of government activity following the war. The first principle that I would lay down is that our public works, like every other form of postwar activity, should be on the basis of utility and nothing else. To quote the National Resources Planning Board report:

"These public works must be to provide the maximum of public service for the minimum outlay of labor, materials, equipment and public funds. . . . The postwar program that we undertake will be in reality the postwar version of our regular public works program rather than a special purpose program set up parallel to a program of regular activities. Such a program will insure the maximum contribution that public works can make to postwar adjustment."

Now I don't believe that it is possible for any group of men in Washington or anywhere else to draw up a rigid and detailed postwar public works budget for the country. That is a continuous job. It is a job that must be decentralized. It is a job that must be undertaken simultaneously through many agencies throughout the country, because it must be budgeted on the basis of its immediate utility to the people who will use these facilities and who in the long run must pay for them.

I want to cite some figures that may mean little or much, depending upon how the basic figure may be realized. A figure that is much used by those who are planning for the postwar economy is that of 135 billion dollars of national income. Now, if we should realize a national income of 135 billion dollars, we might with justice, based on past experience, allocate approximately 16½ billion of that for all forms of construction, both public and private. Of this construction program of 16½ billion, we might with propriety estimate that some 30 per cent, or 5½ billion dollars be expended for public construction. I submit to you that 5½ billion dollars for public construction represents a very substantial budget to carry on the public works of this country in the period immediately following the war. I have no expectation that that total could be achieved in the first year following the war, but it is, nevertheless, a mark to shoot at, based on the assumption of a 135-billion-dollar

national income. Any attempt to swell the total beyond that figure, it seems to me, will carry us over into the phase of "pyramid building," which would have for its purpose not the provision of useful and usable public works, but rather the purpose of using public works expenditure as an instrument for effecting radical changes in the nature of our economy.

A public construction budget of 5½ billion dollars amounts to about $40 per capita. From 1915 to 1929 public works expenditures in this country increased from $9.89 to $26.55 per capita, so that these estimates based upon 135 billion dollars national income are not out of line when you consider the large deferred volume of public works and the higher standard of living that necessitates a larger amount of public investment per capita in this country.

But we must keep one point in mind as we approach the practical problem of drawing plans for such a program. We should not expect to swing too much of our resources into public works during the immediate transition period following the war, since, as I have indicated, our chief task then will be to reconvert our industries—including, incidentally, the industries that will be required to serve the water works program of the country as it gets under way—into production on civilian goods to match our high purchasing power. That will be our one paramount job for the period immediately following the war. Any excessive public works program at that time would but add to the inflationary danger by increasing the amount of money in the hands of the people without a commensurate increase in the volume of consumer goods that would be manufactured and offered to them for sale. Everything that we do in that way to increase the amount of money flowing out into the hands of the people without a commensurate increase in the volume of consumer goods produced will simply enhance the danger of an inflation that already is menacing.

Timing, therefore, is a matter of the first importance in planning our post-war public works program. I assume, of course, that just as quickly as possible the deferred essential services must be put promptly in hand. I refer to the deferred construction of water works, sewerage, pavements, the reconstruction of highways and all the rest that is now neglected in the interest of the war effort. That is an immediate task to be undertaken just as soon as we are able to divert our energies from war to peace. That should come first.

I recognize also the need for a great many new forms of public facilities. The expansion of civilian aviation, for example, will bring about a new need for airport development. The contemplated large program of new home construction submits a demand for public facilities to serve it; the elimination of slum areas on a large scale, which well may be undertaken in the post-war period once again creates such a demand. There will be ample demand for public facilities in the period immediately following the war—urgently necessary demands—so I do not see that it will be necessary for us to whip up artificially any great program of public works construction.

Co-ordination of Private and Public Works

We must remember always that whatever industrial expansion is contemplated by private enterprise in order to realize higher living standards for the American people always has its counterpart in the expansion of the public facilities required to service that

expansion. We can't have an expansion of private industry in this country without at the same time having an expansion of the public facilities that are necessary to service that industry and the people employed by it.

Too often public facilities and private facilities are considered to be competitive. Too often we are submitted a choice between private facilities and public facilities. They are not competitive. They are, and should be considered as, supplementary. I know of no fixed numerical ratio between public and private expansion of facilities, but I do know that they move always in a parallel and that they are interdependent. That will be especially true during a period when both public and private enterprise have been starved by the exigencies of the war and when both of them, of necessity, have deferred their activities until we could turn back to them at the end of the war.

If we regard public works in this light, as essential service facilities geared to the rest of our economic activity, we shall not go wrong in making our plans for postwar public works. For public works, soundly conceived, soundly built, soundly administered, are an essential element of the physical plant that constitutes the capital of the American people—the physical plant that provides a physical basis for the human welfare of the people as well as for their agricultural and industrial activities.

Decentralization of Planning

One more point: *Most public works are carried on by municipalities rather than by the states or by the federal government. Whatever collaboration we may get from the federal government in guidance, in engineering help, in financing, the bulk of our public works—and this is not understood by many of the people who toss public works programs around so recklessly—the bulk of public works is local.* It is municipal, it consists of projects that serve our cities and our towns and our villages.

Postwar planning, therefore, as I suggested a few minutes ago, should be decentralized. I mean, of course, postwar planning for public works. No central agency can draw up a master blueprint to provide for the vast variety of services that are covered by the American public works program in total. Now is a good time for us to do this planning, for us to do the planning locally. And here I would suggest to you who are so vitally concerned, whose personal futures and whose professional careers are bound up with this problem of public works planning, construction and administration, that now is an awfully good time to get the business element in your community on your side. The business men in every community should be taking a constructive interest in the public affairs of their community. They should be doing it as a matter of self-preservation, as a matter of self-interest.

Relation of Public Works to the Business Man

There is no question but that after this war the government—federal, state and local—will have a much greater part in the lives of the American people and in their business affairs than it ever had before. And the business man is awakening to the fact. He is beginning to realize that he is of the community, that he is not apart from it, that the community isn't on one side of a wall and he on the other, that what the community does is bound to have a terrific impact upon his own welfare

and that what he does is bound to have a just as terrific an impact upon the welfare of the community. If we can interest the business men and industrialists of our communities today in sound, useful public works, we shall be able to help them see the whole matter in a new light. We can help them to see, for example, that the American standard of living is not merely a matter of gadgets, that it involves services as well as gadgets and that many of these services are matters of community concern.

The American standard of living is vitally dependent, for example, upon our sanitary sewage disposal, our public recreation facilities, our general education, a reasonable conservation of public health, ample and safe water supplies. These are provided, all of them—these essentials to the American standard of living—through a variety of public agencies whose fixed facilities we call by the name "public works." And these public works are just as vital to the American standard of living as are the factories that turn out our automobiles, washing machines, vacuum cleaners and motion pictures. We have a chance today to convince the American business men and industrialists of that as they never have been convinced before.

And there is another job that we can do. We can convince the business man or the industrialist that there are certain types of public works that are essential to him, not merely as one citizen of the community but as a business man—facilities that are essential, if you please, to the conduct of many forms of private enterprise. Let me cite but a couple of examples. Our highways are the foundation upon which the entire automotive industry is built and I don't mean just the manufacture of cars, the production of gasoline or the manufacture of tires. I am thinking of insurance. I am thinking of tourist camps. I am thinking of the hotel business. I am thinking of the filling-stations, the garages, yes, even the humble hot-dog stands. Many forms of private enterprise in the United States have no existence except for the public investment in our highways that makes them all possible.

Then there is flood control, irrigation, soil and forest conservation, all of which make a direct contribution to the creation of agricultural wealth and to the maintenance of an agricultural economy built upon private enterprise. These are all examples of what public works mean to the business man, to the industrialist and to the citizen. But, unfortunately, too many of our business men have been led to look upon this term "public works" as somehow tied up with the conception of a collectivist, managed economy. Somehow or other, public works are synonymous to him with deficit spending by government. Somehow, he thinks of public works as an agency through which those who could change the form of our economy are planning to work. And that is unfortunate.

Those of you who are in charge of the public works in your communities, it seems to me, should use this opportunity to get more closely in touch with those who hold these mistaken views and to bring them around. You can help them to see that there is no essential difference between the public facility that is built upon the same basis of creating wealth, of creating value for the people of the community, and the private enterprise that is designed to produce and sell some commodity that the people want and use. It is our chance today to win their

understanding and support for legitimate public works and to show them that adequate public works are essential to their own interest and well-being as business men, as well as citizens. And I say to you that business men today are more conscious of social and community values than they ever were before.

Thus, I close on the note that the place of public works in the postwar program is not the same place that we were staking out for it ten years ago. Then, we were in a fainting economy. Then we needed an economic shot in the arm. Today we are in an economy overstimulated and overinflated. It is not necessary to sell public works on any such basis today.

You will be smart in your own interest and in the interests of the people you serve in your several communities if you hew to the line in presenting your public works programs based upon logic, reason, need and economic justification. I am sure that if you do that, you can get the support of the business and industrial interests for every reasonable need of the communities that you are trying to serve.

Planning the Postwar Water Supply Program—Abel Wolman

COLONEL Chevalier has carefully prepared for you the ground with respect to public works in our national economy. I was glad to have him outline for you the first principles which I think any sane, any logical, any competent citizen of this country would be likely to accept.

He has properly pointed out to you that we should strip this particular field of a number of the bogeymen that have been accumulated over a period of ten strenuous years. I am not so sure that I need prolong that introductory phase for you except to say that it would be a welcome step forward if we were to add to the series of objectionable features in public works planning which should be forgotten very promptly. I refer even to nomenclature, in the descriptions of individuals who are interested in planning with respect to postwar periods.

It was entirely conscious on my part that early this week I got a haircut preparatory to avoid being accused of being a long-haired utopian planner. It was an attempt to get out of the classification of utopian, long-haired academicians, into which group one is placed the minute he starts thinking about what may come next year or the year after.

Secondly, I certainly want to be eliminated from the class of defeatists—those people who are not anxious or are certainly unwilling to think ahead in postwar terms. One recent author has described that group as "the people who refuse to cross their bridges until they have been burned behind them."

I do not share that particular view. I like, if possible, to feel that you may classify me at the end of these remarks in what we call the "realistic group." I do not refer to those so-called realists who are unwilling to see too far ahead, are afraid to be left by the bandwagon and manage to climb on half-way down the road when it is fairly clear where the bus is going.

The true realist, operating in the middle ground between the perfectionist and the opportunist, has a reasonable position which I want to present to,

you, largely with specific reference to the limited and simple field of public water supply facilities. I think of this position as far less complicated, far more familiar and far less difficult to conceive of or to plan for than is generally supposed.

The Need for Planning

Colonel Chevalier has described several possibilities of the postwar period. I am not enough of an economist, certainly not enough of a prophet, to determine whether he is right or wrong. He has safeguarded himself through his long experience by telling you he did not know whether he was right or wrong. There will, however, be—and he and I agree fundamentally on this—a postwar period in the United States. Failing some geological cataclysm, we are assured of that one assumption; and it is a rather basic assumption, simple as it sounds, that there will be a postwar period.

It may be one of high prosperity. It may be one of great inflationary difficulty. It may be one of short-term transitional difficulty, but we will be here, or at least some of our associates will be here who are hardier than the Colonel and I.

Therefore, there is every excuse, and we seem to need one, for talking about that postwar period, even though it may be overdignified by calling it long-range planning, even though it may be overdignified by insisting that we must make over the world within that next ten-year period—say, of 1944 to 1954.

It is quite immaterial to the purposes of my thesis as to whether we think of it on the long-range basis or on a short-range one. The point I want to make with reference to it is that we should insist upon a perfectly orthodox thinking ahead.

I find it curious to have to combat the desire to avoid postwar planning in many sections, because thinking ahead has always seemed to me to be an orthodox process. If I recall, it dates back over 150 years. It has only come under disrepute, apparently, in recent years. If you want to look ahead more than twenty minutes, it is now considered to be either New Dealism or a prelude to collectivism. I do not really think it means that.

It means we have to resume a balance in our point of view, we have to regain our equilibrium and insist that it is good business, it is wise public policy, it is desirable public policy to look ahead. That is peculiarly true in the water works field, where we have often been chided by city councils, by mayors, by county commissioners for looking ahead too far, looking ahead perhaps even as long as ten years, which is, of course, an awfully long time to a city council which only looks ahead to the next election.

But, as water works people, we have always looked ahead in terms of ten, twenty and thirty years. Now, when we do that, we introduce a concept of the desirability of what I call a "ten-year thinking." And ten-year thinking, again in the water works field, is a simple concept with which we have all been associated in the past.

Inventory of Requirements

When we do that, what are we confronted with in the specific field of water production, treatment and distribution? That is our first necessity—the determination of need in the postwar period.

Regardless of how long it is, regardless of economic situations, regardless of whichever party, Republican or Democratic or whatnot is in force, because I have the faint idea that regard-

less of who or what runs the country, after the war there will be, again, not only a postwar period but postwar public works and there will be a public water supply. It is one of the peculiarities of our profession that we furnish something without which even a Republican or a Democrat cannot do. It sometimes seems a calamity but it really is always good fortune that water supply is a necessary service and one which, incidentally, does not recognize political boundaries or political complexions or political distribution.

When we try to estimate that postwar need, one way of doing it, of course, is by reviewing the past. The past is a prelude to the future; and it gives us a cue as to what we have been accustomed to doing in that field. I hesitate to use statistics, but in instances of this sort it is necessary to introduce a few figures.

In the period from 1920 to 1930 in the water supply field we spent on the average about 130 million dollars a year. That is a figure to bear in mind as a base from which we step off. It was quite independent of any other situations. It was a current keeping up of our normal municipal housekeeping. It was desirable for servicing consumers, for industries, fire protection and so on, and it averaged about 130 million dollars a year.

You may recall that at one time during that period we had a platinum age. It did not last long, but in that flush year of 1930 we spent 200 million dollars in the water supply field. Some of us may regret that we were quite that exuberant, but we did it, and we did it for reasons which appeared to be good at that time.

At present we furnish public water supply in this country to about 85 million people. We estimate that, during the next ten-year period, we will have, in addition to the increment of some four to nine million people that have come into the metropolitan areas in the last ten years and who are now unserved by public water supply, an additional population growth of a normal character. It may be slow. It may be disappointing to some. It may be the result of a variety of other checks and balances, but the curve is still upward and is likely to remain so over the next ten-year period.

Thus, on the basis of those three or four fundamental facts—what we spent before, what we have had in increased population up to the present date, what we are likely to experience over the next ten years—we have three sets of cues by which we may determine what our needs will be from, say, 1945 to 1955.

Now what do they appear to be? Our present population increase indicates that as soon as the war is over about 20 million dollars a year of expenditures will be required to catch up with new people, people who at the moment need water supply but cannot be supplied with that necessary service.

We will have, secondly, what we call current replacements, because of our delayed maintenance, because of our lack of opportunity to get materials and equipment, of about 72 million dollars a year. It is the lag in our previous accumulated deficiencies. We have also a series of new deficiencies which will start or which have started and will accompany us on this highway during the next ten years and which will amount to 18 million dollars a year for new population growth and for the service which they should receive.

We have a good deal of substandard equipment in the field in operation today only because we do not find it possible to replace it. We estimate

that that will require in the neighborhood of 59 million dollars a year for the next ten years. Many of us believe that there will be a great deal of new housing during the next ten years. It is variously estimated, depending upon the enthusiasm of the individual, his experience, his hopes, his courage, perhaps even his political complexion, but, regardless of these factors, all seem to feel that somewhere between ½ to 1½ million new houses will be necessary annually during the next ten-year period, which, in turn, will require about 50 million dollars a year in water works expenditures.

Those of you who have been carefully jotting down these figures can accompany me while I add them up. They represent approximately 218 to 220 million dollars a year for the next ten-year period. It does not sound out of reason in comparison with the average in the previous decade, 1920 to 1930, of 130 million dollars a year. It is not outlandish, as I say; it is within the realm of possibility and even if it falls below or above that figure by several million dollars, it is not of any great importance in relation to our topic.

Program for Immediate Action

Now what about it? The things that should be of interest to the water works people are not so much that we will be confronted, in round numbers, with something approaching a quarter of a billion dollars a year in water works expenditures, but what we ought to do about it at this particular time. I do not mean tonight, because we intend to give you a waiting period until tomorrow morning before you start preparing for this enterprise, but it is important to consider what ought to be done in the interval between now and the end of war, which we all hope will be a shorter period than we anticipated a year ago.

Here again, there is a series of simple things to do. They are orthodox. They are not peculiar to any special regime. They are sound from an engineering standpoint, sound from a public standpoint. I list only four or five of them, not necessarily in the order of their importance.

1. Analysis of Local Needs

They are, first, as Colonel Chevalier has properly pointed out, the analysis of your local requirements and needs. I want to add a word regarding that local appraisal of what you will require in the water works field over the next ten years. It is an appraisal that must be made locally. It is not purely a literary cliché to talk about local responsibility. It is a fact. The local people are the people who ought to know.

I have only one criticism when we talk about it. It is a criticism I have voiced for as long as ten years, since the last public works program. Talking about local responsibility is a different thing from practicing it—and that should sink in with most of the local representatives here today. You cannot talk local responsibility and sit around waiting for a telegram from Washington that you have been awarded a million dollars to start work. That is not my definition of local responsibility, either for appraisal or for beginning the number two job that I have listed here. And I want to emphasize it for this reason: Many of you think that it is an unfair charge, but I could list, if I had the time and the stenographers and the adding machines, approximately 13,000 municipal officials out of 13,500 in the water sup-

ply field who are doing this very minute just what I have described. They are waiting for the passage of some kind of an act—HR60476 or Senate Bill 34579—that will do what? It will permit you to continue to talk about local responsibility and to spend federal money.

It is the most comfortable position I know that you can be in, at least temporarily, because it is only temporary. I make the charge, and I hope the Colonel will forgive me for making it. I am quite sure he will, because this is the time when local municipalities, counties, states, should be using some of the money which they now have to do some of this appraisal without taking the first train to Washington to see whether somebody there is going to see to it that they get the money. In other words, some are fed up on the conversation about local responsibility unaccompanied by action in local responsibility. And it is a lesson I should like to leave with this group, so that when they go home they can look into their own reserves, into their own accumulated incomes, to see whether it really is not possible—rather than outlandish or fantastic—that they might employ a competent group of consulting engineers to make the appraisal for them before they discover whether or not a remote Santa Claus in Washington is going to do it for them.

There are several bills in Congress today—most of you are following them with great care, because you should not miss any tricks—that will do just what you are waiting for, but why do you wait? If you really believe in what Colonel Chevalier described as local responsibility, why don't you demonstrate that you have, in addition to local autonomy, local responsibility; because, again, as I pointed out before, every dollar that you get from Washington first of all is your own. Remember that. Secondly, it carries a certain irritating responsibility with it which you do not like. But you must remember that, unless it is distributed on the street corner, sight unseen, it must carry certain strings attached to it. If all the municipalities in the United States were poverty stricken, I could sympathize with them, but I do not believe they are.

When we talk about inflation possibilities we cover both private and public money. Every municipality, every county and every state in the Union that today reduces its tax rates in order to have more money flow into public buying, in order to avoid the establishment of reserves for postwar use, adds just that bit to the severance of local responsibility and to the creation of central control.

2. Authorization of Project

The second item in my program is the authorization of the project. That, too, is leisurely waiting around to see what Washington is going to do—waiting to see what that distant angel or devil, depending on how you want to describe it and on whether the check arrives on time or whether it arrives with a restriction—is going to do.

Again I say, why wait? Why not determine what your needs are authoritatively and go forward with them? Authorize your project.

3. Preparation of Specifications

Thirdly, prepare your detailed plans and specifications. The opposition to that step, which I find throughout the country, is very interesting. Whether it is a rationalization or not, I do not know. When you say prepare plans,

and specifications for new water supply, one of the answers is: "Well, don't do that now because there is going to be such a marvelous and mysterious after-war set of new products. Instead of cast-iron pipe we are going to have *papier maché* or something else, instead of a pump we are going to be able to look at the water and it will climb 150 feet to where we want it. We will be using electronics. . . ." That fear, or rather that hope, for the mysterious is another retardant.

I think it is reasonable to say that it will be a marvelous world. There will be many of the war developments in technology translated into peacetime water supply use. But here again, we may prophesy with a little bit more courage and a little bit more assurance. It is not likely to revolutionize the distribution system of the average municipality. It is not likely to revolutionize the pumping system. It will do some things in the treatment processes, but they are not likely to be of such heroic nature that the mere studies of their desirability and need should be avoided.

The same thing is being said about houses. I do not know what kind of house we are going to live in in 1945 or 1946 or 1948, but, in talking to some people who want to avoid thinking ahead, I have heard it said that you should not design or think or touch that kind of a field because some kind of a miraculous house, without walls, without heat, without kitchens, without food, will be available after the war, in which all you will have to do is carry around a small box. Even assuming that vast improvements in the housing field will take place, I suspect that we will be able to recognize a house as we have designed it in 1943 when we pass it in 1947. I merely suspect that. It may look odd to us, but we will know what it is. Of course, that is no great improvement over the kind of houses we have been distinguished for in Baltimore for many years, where you never knew where your house was in a block. The house couldn't be any more mysterious than our row house in Baltimore always was—where every house looked like the next door one and you frequently went into the wrong house or the right house—but there will, again, be something for which you must supply a water service.

4. Appropriation of Funds

Fourth, we certainly should consider the question of providing, in the next ten years, for the appropriation of funds. That does not mean that the mayor and the city council will sit down and say: "We think you have sold us. You have sold us on the idea, and, therefore, we should have some money." It means more than that, as every water works man knows. It means going through the various steps of legislative procedure, of authorization, even of a referendum. Certainly some of those steps should be taken in the immediate future, so we do not experience what we did in 1933—a lag of nine to eighteen months before there was a pick in the ground or a steam-shovel at work on projects that were said to be ready to go. We have the same set of projects today, not exactly the same set, because we have built some, but we have lists flowing into Washington which are remarkable not only for their size, and I can tell you they are remarkable for that, but regardless of their size, they are remarkable by their presumed readiness to go, which, frankly, is the bunk. They are not ready to go. They are merely lists on a piece of paper. They are descriptions of a hope. They are not con-

struction drawings or specifications. They carry no land, no right-of-way, no authorizations, no legislative requirements already met.

I want to emphasize, too, that every mayor who submits a list of his postwar projects to the newspaper—and I have seen many of them, aggregating 90 to 100 million dollars—is fooling his public. Those projects are nonexistent, except, as I say, in the hope that you may some day build them. They are not the kind of thing we are talking about tonight.

In addition to having a major problem of preparation in the physical field, where do we get the money? Locally or centrally? Are we prepared by legislative authority to get it? Are we prepared in our taxation scheme to provide a way for paying for it? Most of us are not. There are a few public enterprises in this country and in Canada which, during the last year, have set up legal authority and are setting aside money reserves for the very purpose we are talking about. In our own state within the past two months a legislative act has been passed authorizing every community in the state to establish postwar reserves today, to set aside part of its income so it is not completely free of money at a later time. The federal government has introduced several acts, none of which has passed at the moment, which provide the same thing for public enterprise and—some of us hope—for private enterprise, setting the stage, as it were, for the fiscal aspects of your program.

5. Administrative Organization

Lastly, I want to refer to the very complicated administrative and political decisions and arrangements that we have to make, likewise for the next ten years. Here I get into a very difficult problem of American political subdivision. I have referred to it before at some of these meetings; I stress it again. The water works man and the general public works man is in general bound by political subdivision boundaries. He is bound by a map on which there is a black line that says: "This is the boundary of St. Louis," or "of Kansas City," or "of Baltimore," or "of Philadelphia" or "of Detroit." Actually his community has disappeared from within the bounds of that line. It has been confined only on the map. It has spread by virtue of a thousand reasons into a territory which he frowns upon. He frowns upon it in a dozen ways—by his restrictions toward extensions, by his control of what goes on inside as distinct from outside. He is bound, as I say, by a political boundary line of 1800 and his water supply service operates on the basis of resisting the growth of the metropolitan area or the growth of the region. We require, therefore, in parallel with these things of which I have spoken, an adjustment in political boundary thinking, a reorientation so that our boundary of service of water will begin to parallel the boundary of metropolitan and regional living, because it has escaped from the boundary of the city. A kind of geographical surgery is required during the next ten years. The term I borrowed from Lord Bryce. Curiously enough, he referred, in his visit to this country many, many decades ago, to the necessity of geographical surgery in order to meet the requirements of man. What I am suggesting is a kind of geographical plastic surgery. By that I mean adding to our municipal boundary lines a kind of metropolitan form that will be less amorphous than it is today, better designed and more really approaching a

kind of living entity. The kind of geographical surgery that Lord Bryce referred to many years ago should accompany our planning in the water supply field.

Inter-association Action

Although I may not have exhausted the subject, I certainly have exhausted you, but I want to refer to one more item. Within the past few months this whole problem has been given serious consideration by three of your national organizations—the New England Water Works Association, the Federation of Sewage Works Associations and the American Water Works Association. These organizations hope to join interests in some central group which will make it its function, during the next two to three years, to develop on an educational basis the ideas which both Colonel Chevalier and I have tried to present to you—in other words, to introduce throughout the country as skillfully, as reasonably and as accurately as it can, what these necessities are, how the problem can be approached locally, what you should do to recover, not local autonomy, but local responsibility, how you can best use the professional brains and services which you have and how you can carry your public with you so they can accompany you along a road, not to a millennium, but to a reasonable American way of life.

Water and Sewage Works Postwar Planning

Following action taken by the A.W.W.A. Board of Directors on June 15, 1943, representatives of the various associations participating in the postwar planning activity held a preliminary meeting in Cleveland.

An organizational meeting is being held in Washington on July 16, at which time the scope of the work to be done is the primary topic.

Mr. Abel Wolman has agreed to act as General Chairman. The representatives of the constituent associations are:

Federation of Sewage Works Assns.: C. A. Emerson, G. J. Schroepfer

New England Water Works Assn.: E. S. Chase, Roger W. Esty

Water & Sewage Works Mfrs. Assn.: C. H. Becker, C. A. McGinnis

American Water Works Assn.: H. E. Jordan, S. B. Morris

A Quarter Century of Development in Cleveland's Water Supply

By A. G. Levy, S. C. Simmermacher and L. A. Marshall

General Development of the System—A. G. Levy

DURING the last quarter of a century the Cleveland area has witnessed one of the greatest water supply developments in its history. At the beginning of the period, Cleveland was furnishing its own 754,000 inhabitants and about 99,000 of its neighbors in fourteen suburban areas an average of about 110 mgd., only about half of which was filtered. It supplied this water through 1300 mi. of mains, not over 300 mi. of which had been built in the suburbs. Today, filtered water is being supplied to all of Cleveland's 920,000 population and to 360,000 other persons residing in 49 cities, villages and townships throughout Cuyahoga County, one village in Summit County to the south, and three villages in Lake County to the east. An average of over 190 mil.gal. of water is now being pumped through 2852 mi. of mains, 1315 mi. of which lie in the suburbs. This development of the suburban supply and distribution system has so expanded the general water system that all of Cuyahoga County which has a public water supply, except the city of Berea and the village of Chagrin Falls, now forms a part of the Cleveland Water System. To accomplish this development, the city itself has spent nearly $36,000,000. This amount is in addition to that spent by the suburbs on the development of their own distribution systems and that spent by the federal government through WPA and other agencies.

The soldiers of the World War had hardly been mustered out of service before Cleveland began the study of a comprehensive plan for the development of a water supply on a metropolitan basis. Following studies made by the Water Division's own engineers, a "Special Consulting Commission on the Extension of the Water Supply System of the City of Cleveland," consisting of J. W. Frazier, James H. Herron and Robert Hoffman, was appointed on June 18, 1919. In its report issued under date of June 1, 1920, this Commission stated:

"The subjects called to the attention of this Commission, for its consideration, may be classified under the following headings: (1) the territory and population to be ultimately supplied with water by the City of Cleveland;

A paper presented on June 15, 1943, at the Cleveland Conference, by A. G. Levy, Engr. of Constr. & Surveys, S. C. Simmermacher, Mech. Engr., and L. A. Marshall, Supt. of Filtration, Div. of Water & Heat, Dept. of Public Utilities, Cleveland.

(2) the increased demand for water to be encountered in supplying the city and adjacent territory; (3) the location and capacities of water tunnels required to meet the growth in water demand; (4) the pumping facilities required to deliver the water to the consumer; (5) the necessity, size and location of future filtration plants; and (6) the plan of procedure to be followed and the tunnel capacity by additional pumps and appurtenances. The Division Station should receive immediate attention and the Kirtland Station should be improved in connection with the Baldwin Filtration Plant development.

2. The planned Fairmount Pumping Station should be built as early as possible and related to the Baldwin Filtration Plant development.

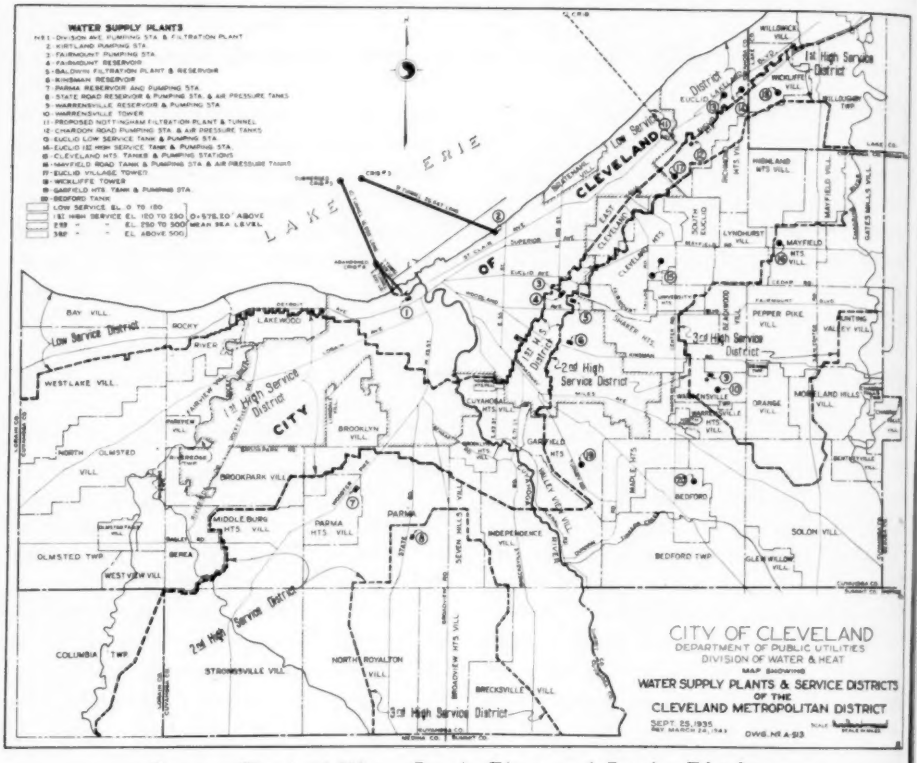

WATER SUPPLY PLANTS
LAKE ERIE
CLEVELAND
CITY OF CLEVELAND
DEPARTMENT OF PUBLIC UTILITIES
DIVISION OF WATER & HEAT
WATER SUPPLY PLANTS & SERVICE DISTRICTS OF THE CLEVELAND METROPOLITAN DISTRICT
1st High Service District
2nd High Service District
3rd High Service District
Low Service District

FIG. 1. Cleveland Water Supply Plants and Service Districts

relative order in which the improvements should be made."

As a result of the study of this commission the following principal conclusions were drawn and recommendations made:

1. The existing pumping stations should be brought up to their respective

3. The construction of the planned Baldwin Filtration Plant should be begun as soon as possible, making use of the existing Fairmount Reservoir as a receiving basin for raw water to be pumped through special mains from the Kirtland Pumping Station.

4. The Division Filtration Plant should be brought to full capacity

through such repairs and additional construction as may be necessary.

5. The planned East Side Tunnel and Pumping Station should be begun at an early date.

6. The second high service district on the West Side should be provided with the necessary pumping station and standpipes to make it possible to reach the Parma district.

7. The filtration plant, to be used in connection with the new East Side Tunnel, should be planned so as to be in service when required, soon after water is regularly supplied from that source.

8. A new west side reservoir, for the first high service, should be constructed.

9. Service lines should be extended so as to supply the third high service district, on the West Side, and a pumping station and standpipe should be constructed in order to deliver water to this district.

10. The planned West Side Tunnel and Pumping Station should be begun at an early date.

11. The filtration plant to be installed in connection with the new West Side Tunnel should be begun so as to be in service when required, soon after water is regularly supplied from that source.

12. The reservoir for the second high service on the east side should be increased in size.

These recommendations laid the foundation for the general plan of progress followed since then. Other reports made in later years have amplified and expanded certain phases outlined in the report, but the general plan given therein is still being followed. The depression, of course, slowed the progress of the plan and a report issued in February 1940, by an "Advisory Board of Engineers," specifically called for a delay in the construction of the East Side, or Nottingham, Filtration Plant and Pumping Station, until after 1950.

There are six major divisions into which may be separated the general plan of progress in water supply in Cleveland during the last quarter of a century:

1. Rehabilitation of the Division Filtration Plant
2. Baldwin-Fairmount project
3. Parma Reservoir and Pumping Station
4. Nottingham Filtration Plant and Pumping Station
5. Warrensville Reservoir
6. Supply mains.

1. Rehabilitation of the Division Filtration Plant

Prior to the quarter-century period under consideration, structural and foundation difficulties had developed on a large scale in connection with the Division Filtration Plant and some remedial measures had been undertaken. Except for the relining of the filtered water reservoir, however, these measures had been on a comparatively small scale. One of the first problems to be investigated after the issuance of the 1920 Report, therefore, was that in connection with repairs to the Division Filtration Plant.

Pipe Vault: At the west end of the filters where a high fill existed, considerable settlement had taken place, requiring the razing of a portion of the filter superstructure at that location. Partly responsible for the condition of the superstructure was the overturning action of the heavy earth load resting on a concrete Venturi vault extending beyond the westerly limits of the filter building proper and tied into it by

heavy steel reinforcement. To relieve the supporting strata, permanently, of the load produced by the high backfill, and, further, to increase the accessibility of the numerous large mains at this location, the entire Venturi meter vault, together with the backfill, was removed and a reinforced concrete pipe vault constructed. This new vault was supported on 7880 lin.ft. of reinforced concrete piles and extended across the entire west end of the filter building. To preserve the appearance of the grounds, the roof of the vault was designed to permit a 2-ft. earth covering, which could be planted in grass. The contract for this work was awarded in February 1922 and included, in addition to the pipe vault itself, the furnishing and driving of 8051 lin.ft. of precast sectional piles under the east and west effluent galleries of the filter building.

Underpinning the Effluent Galleries: The sectional piles in the effluent galleries were designed to be driven through the bed of peat and quicksand underlying the entire site of the Division Filtration Plant, into the clay stratum below it. They were made in 5-ft. lengths, 14 in. in diameter, with provision for connecting adjoining sections by means of lugs and recesses. They were forced into the ground by hydraulic jacks, bearing, at their upper ends, against the underside of the filter gallery roof supports. These piles were driven through a hole cut in the heavily reinforced concrete gallery floor and the support was carried from the pile to the filter structure by means of a concrete cap resting on top of the pile and extending underneath the edges of the hole.

In October 1922, another contract was awarded for driving sectional piling under the effluent galleries, to complete the second and final stage of underpinning called for under this part of the plan of rehabilitation. The work under this contract resulted in the driving of 20,015 lin.ft. of piling. With the completion of the program of underpinning in the effluent galleries, that portion of the superstructure which had been razed was rebuilt, being completed in April 1925.

During 1923, 1924 and part of 1925, most of the attention of the Division of Water was concentrated on the completion of the Baldwin-Fairmount Project, designed to assist in furnishing the entire city and that part of the suburban area connected to the Cleveland Water System, with its first supply of completely filtered water. When this project was completed in October 1925, a concerted effort was made to solve the problems of final rehabilitation of the Division Filtration Plant.

Steel Sheet Piling: As previously explained, underlying the site of the Division Filtration Plant, particularly the settling basins and the filter and administration building, is a bed of peat and quicksand overlying stiff clay. About 375 ft. north of the filters and administration building is a branch of the Cuyahoga River near its confluence with Lake Erie. To provide some method for holding this more or less fluid material in place and preventing its moving toward the river or being washed therein by leakage through the badly cracked floors and walls of the settling basins, a row of interlocking steel sheet piling was driven along the north, east and west sides of the plant. Because of pressure from the hill along the south side, no piling was placed there. A total of 64,400 lin.ft. of piling was driven, all to such an elevation as to provide a minimum penetration of 5 ft. into stiff clay.

Settling Basin Reconstruction: Early in 1926, it was felt that the steel sheet piling was functioning as it was expected to do and that it was time to take some action to stop the excessive leakage which was finding its way from the settling basins into the main drains underlying them. At that time this leakage amounted to 5 mgd. and was steadily increasing. Some of the leakage came from the mud valves forming a part of the system by which the basins are cleaned, but by far the greater part of it was finding its way through cracks in the floor and in the walls. The steel sheet piling had cut off the flow toward the river but there was nothing to prevent the water from finding new channels into the broken drains and thus forming additional sources of possible undermining.

The original floors of the settling basins were inverted groined arches and, in principle, the scheme of reconstruction used consisted of placing, over the original floors, a heavily reinforced concrete mat (Fig. 2) having a minimum thickness of 5 in. at the columns and walls and 17 in. at the crown of the inverted arch. At the junction of the old and the new concrete, asphalt joints of from $\frac{1}{2}$ in. to 1 in. thick were provided. In general, to prevent leakage through the walls, large cracks were covered with a specially designed copper covering while small cracks were filled with a fiber and asphalt mixture calked in place. In one basin, the existing wall was so badly shattered that a part of it had to be removed and replaced with new concrete. In another basin, the entire wall was in-

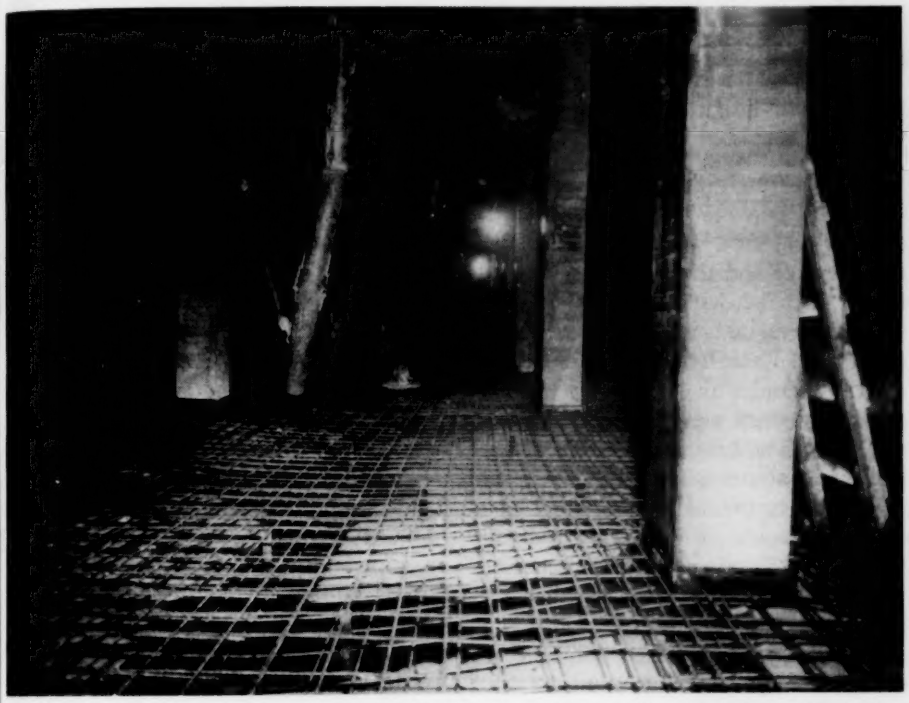


FIG. 2. New Floor Construction in Settling Basins, Division Filtration Plant, Cleveland

capable of carrying any water pressure. To remedy this condition, a heavily reinforced concrete wall was built entirely within the basin leaving the old wall to carry the roof load only.

Coincident with the work carried on in the settling basins, the filter operating galleries were repaired, cleaned and redecorated and the administration building repainted. All unsightly cracks were chipped and filled, and new supports provided, where needed, for the operating gallery floor.

2. Baldwin-Fairmount Project

The water supply system of Cleveland is separated into four service areas (Fig. 1) known, respectively, as the low-service, first high-service, second high-service and third high-service districts, each of which, in order, comprises successively higher ground above the level of Lake Erie. The low-service district includes all areas lying between the lake and an elevation 120 ft. above the lake. The first high-service district comprises all areas between 120 ft. and 250 ft. above the lake; the second high-service district, all areas between 250 ft. and 500 ft. above the lake; and the third high-service district, all areas above the 500-ft. level. In addition to this division into service districts, the system is separated into an East Side and a West Side by the wide valley of the Cuyahoga River, with connections across the valley for the low-service and first high-service districts only. One tunnel and intake crib forms a source of lake supply principally for the West Side and one similar combination, the source of supply principally for the East Side. Again, just as the Division Filtration Plant and Pumping Station with its supply mains forms the principal source of filtered water supply for the West Side, so the completed Baldwin-Fairmount Project with the other East Side supply mains existing at the time of its completion is the principal source of filtered water for the East Side. The Baldwin-Fairmount Project comprises the control works in Fairmount Reservoir, the Baldwin Filtration Plant and Reservoir, the Alum Storage House, the new Fairmount Pumping Station, changes in the Kirtland Pumping Station, the transmission mains, and the mains leading from the reservoirs and pumping stations to the various service districts supplied.

Flow of Water: Prior to the construction and placing in operation of the units comprising the Baldwin-Fairmount Project, water was taken from the lake, chlorinated and then pumped by the Kirtland Pumping Station into the East Side low-service district, with the Fairmount Reservoir acting as a balancing reservoir. In addition, water was taken from this reservoir and repumped into the first and second high-service districts. Since the completion of the Baldwin-Fairmount Project, raw water has been pumped through transmission mains directly into Fairmount Reservoir from which it is repumped to the Baldwin Filtration Plant. After filtration the water passes into Baldwin Reservoir, flowing by gravity from this reservoir into the low service district on the one hand, and back to the new Fairmount Pumping Station on the other. The new Fairmount Station then repumps the filtered water into the first and second high-service districts.

Transmission Mains: The transmission mains by which the raw water from Kirtland Pumping Station reaches Fairmount Reservoir consist of one lock-bar steel main and three cast-iron mains, each 48 in. in diameter and

about 7500 ft. long. These four mains combine into two 60-in. lock-bar steel pipelines, each approximately 15,000 ft. long. All of the steel mains were constructed especially for the purpose for which they are being used. The cast-iron mains originally formed a part of the low-service system. No changes were made in them in their shift to transmission mains except to connect them to the two new 60-in. mains and to close off such valves as were necessary to insure a dry section of main in all cases between the raw and filtered water.

Fairmount Reservoir Control Works: Fairmount Reservoir is an open reservoir of 80-mil.gal. capacity, divided into two basins, and is situated about 3½ mi. from Lake Erie. It has paved earth embankments for walls and a paved bottom. The new control works were necessary to fit the basins as a receiving reservoir for raw water. These works control the inlet and outlet of the water to and from the reservoir. Each of the two 60-in. transmission mains leads to a single gatehouse, forming a part of the control works, and each gatehouse is connected to one of the two basins comprising the reservoir. Proper cross-connections and valves permit each of the transmission mains to feed either or both gatehouses. Flow through each gatehouse into the reservoir is controlled by a 72 × 84-in. sluice gate. Overflows, in each gatehouse, capable of taking one-half the capacity of Baldwin Filtration Plant prevent flooding in case of failure to have the sluice gates properly opened. From each gatehouse a 72-in. riveted steel main passes through the earth embankment down the slope and onto the reservoir floor. Upon reaching the floor, in order to give better distribution in the reservoir, the main is headed toward the diagonally opposite corner of the reservoir, sloped slightly upward and increased in size from 72 in. to 96 in. in diameter at the open end. Protection against leakage through the embankment and damage from ice to the pipe on the slope were included in the design.

Each outlet gatehouse is a heavily reinforced concrete structure divided into three waterways, each 4 ft. 8 in. in width, and each controlled by a 42 × 72-in. sluice gate. The three waterways lead to a 12-ft. central well. Water from the reservoir, after leaving the waterways and central well, passes through a shaft and 7-ft. diameter tunnel to the pumps in the nearby new Fairmount Pumping Station. In turn, these pump the water up to the Baldwin Filtration Plant. Granite facing, extending 5 ft. below the water surface, acts as a protection against ice formation in the reservoir.

Baldwin Reservoir: Baldwin Reservoir is a groined arch concrete covered reservoir surrounded on three sides by the Baldwin Filtration Plant. It serves as a reservoir for both the filtration plant and the low-service district. Baldwin Reservoir is about 1035 ft. × 550 ft. in plan and 40 ft. from the floor to the crown of the groined arch roof. It is divided into two basins of equal size. The maximum depth of water is 36.5 ft. and the two basins have a total capacity of 135 mil.gal. In all, 1196 round columns 30 in. in diameter on centers of 20 ft. 3½ in. support the roof (Fig. 3).

Baldwin Reservoir is built entirely on shale or rock, with column footings separate from the floor. A subfloor, with a minimum thickness of 3 in., rests directly on the shale with a finished floor 9 in. thick above, unreinforced except over the drains. On the

north, east and greater part of the west side of the reservoir, the back of the walls are built against the rock, and advantage of this was taken in the design. The average thickness of concrete in the roof above the springing line of the groined arch is $8\frac{5}{16}$ in. Two rows of stiffening walls, at right angles to one another, were built between two adjacent rows of columns across the center of the reservoir. These walls are so laid out as not to interfere with the flow of water. Necessary drains, wall and discharges over submerged weirs into the reservoir proper. It flows across each basin to openings, near the bottom of the reservoir, in a conduit built in and forming a part of the opposite wall. These conduits continue separately, in or adjacent to the south and west walls, to an outlet gatehouse. The provision permits the operation of either basin while the other is out of service. At the gatehouse, each conduit is connected to a separate wet well. These wells are cross-

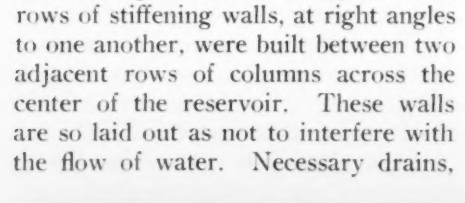


FIG. 3. Interior of Baldwin Reservoir, Cleveland

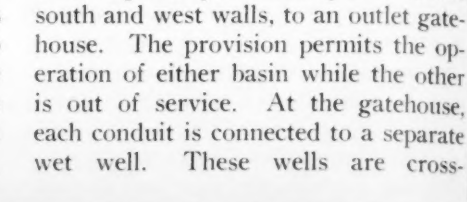


FIG. 4. Interior of Parma Reservoir, Cleveland

overflows and ventilation are provided. The concrete roof is covered with a layer of thoroughly compacted clay puddle 6 in. thick at the crown of the arch. Over this is 1 ft. of subsoil and 6 in. of top soil. The entire top of the reservoir is covered with grass, except where walks have been provided or shrubbery planted.

Water enters at the center of the reservoir, from the filtration plant, flows through a flume built in each basin along the upper part of the north

connected by a 60-in. valved line to permit equalization of the water in the two basins of the reservoir. Leading from the wet wells are three 48-in. and two 36-in. gated low-service cast-iron mains. Leading from the previously mentioned conduits, as they reach the gatehouse, are two 48-in. gated cast-iron suction mains supplying the first and second high-service pumps in the new Fairmount Pumping Station.

Alum Storage House: The alum storage house is located on a switch o

the Cleveland Short Line Railroad about ½ mi. west of the Baldwin Reservoir and adjacent to the new Fairmount Pumping Station. The lack of railroad connections to the chemical house of the Baldwin Filtration Plant necessitated this separate storage building. The building is of reinforced concrete 51 ft. × 87 ft. in plan and 43 ft. high. It has a storage capacity of about 1000 tons. There are four reinforced concrete bins extending across the building, each terminating in three hoppers having sides sloping 50 deg. from horizontal. Each hopper has a single undercut gate through which the alum is discharged. The entire area under the bins is used for truck runways.

The remaining parts of the Baldwin-Fairmount Project, i.e., the new Fairmount Pumping Station, the changes at the Kirtland Pumping Station and the Baldwin Filtration Plant, are considered in Sections 2 and 3 of this article.

3. Parma Reservoir

The first high-service district comprises the largest area on the West Side to be supplied with water. This area has had a well sustained growth during the last quarter century; even prior to the 1920 Report, the need for a reservoir in the area was recognized. The 1920 Report proposed a "reservoir from 75- to 100-mil.gal. capacity." In 1930, however, a restudy of conditions was made and a report issued on "The Future Development of the Cleveland Water Supply System," by a special engineering commission consisting of Robert Hoffman, L. R. Howson and J. H. Herron. As a part of this report it was recommended that the reservoir be reduced in size and that half of it, with a capacity of 20 mil.gal. be built as soon as possible.

Parma Reservoir is located about 7 mi. south and about 1½ mi. west of the Division Pumping Station in the West Side second high-service district. It is a concrete covered reservoir, about 75 per cent of which extends above the finished grade. It is the only architecturally treated reservoir in the system.

The first basin of Parma Reservoir, which has been constructed, is about 378 ft. × 456 ft. in plan and about 36 ft. from floor to roof. The maximum depth of water is 32¾ ft. It has a flat slab roof 11½ in. thick, except at the columns, and an 18-in. thick floor reinforced top and bottom, with the column footings resting on the floor. No subfloor was provided. The walls are of the cantilever type and the footings carry the brick and stone work of the architectural treatment. Columns are in general 30 in. in diameter on 20-ft. or 24-ft. centers (Fig. 4). At all roof expansion joints, double rows of columns, 27 in. in diameter, have been constructed. Necessary drainage, ventilation and overflows have been provided. The roof is fully waterproofed, with metal water stops at expansion joints, and with a membrane waterproofing overlaid by 3 in. of crushed stone. Above the stone 12 in. of earth and 6 in. of top soil were placed. Pattern stone walks are provided next to the parapet wall which rises about 4½ ft. above the walk. The remainder of the roof is grassed.

The architectural treatment (Fig. 5) consists of curtain walls masking the concrete reservoir proper. These curtain walls are of brick, with stone trim, and arranged in the Gothic style of architecture. Towers with massive but-

tresses protect the corners and bastions are placed at the mid-point of the long walls. The walls are surmounted with battlements and the structure looks very much like an ancient castle or fortification.

The brick walls are 17 in. thick, with 17-in. pilasters, in general on approximately 20-ft. to 24-ft. centers, extending back to the concrete wall of the reservoir. Double pilasters are used at all expansion joints. The brick wall is tied to the concrete wall at each pilaster. Weep holes are placed at the bottom of the wall between pilasters, to provide drainage if required.

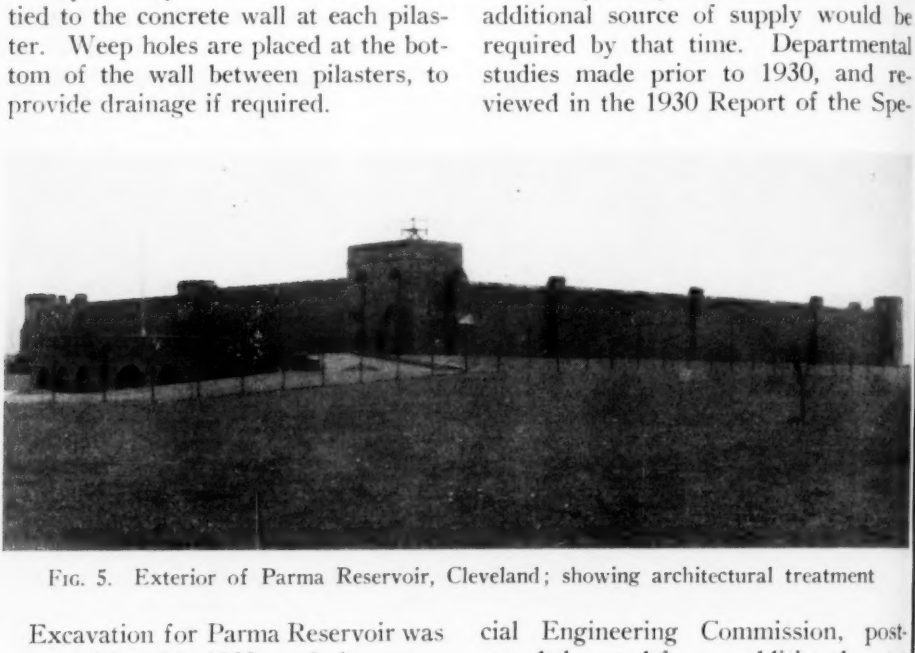


FIG. 5. Exterior of Parma Reservoir, Cleveland; showing architectural treatment

Excavation for Parma Reservoir was started May 31, 1933, and the reservoir was put in operation July 8, 1935. The architectural treatment was started November 9, 1936, and was completed September 1, 1937.

Parma Pumping Station, adjacent to Parma Reservoir, was constructed as a part of the general contracts in connection with the reservoir. It is a West Side second high-service pumping station, operating in conjunction with the 1½-mil.gal. concrete covered State Road Reservoir, which was purchased from the County Commissioners of Cuyahoga County in June 1932. Parma Pumping Station has the same type of architectural treatment as Parma Reservoir.

4. Nottingham Filtration Plant and Pumping Station

The 1920 Report estimated that the capacity of the Baldwin and the Division Filtration Plants would be exceeded by the year 1930 and that an additional source of supply would be required by that time. Departmental studies made prior to 1930, and reviewed in the 1930 Report of the Special Engineering Commission, postponed the need for an additional water supply until 1935. The depression years, however, followed shortly after the 1930 Report had been issued and a decided drop in water consumption resulted. The whole plan of expansion contemplated by the report, insofar as an additional water supply was concerned, was abandoned in 1932 and nothing was done in connection with the Nottingham Filtration Plant for several years. The year 1932, however, saw the low point in consumption

reached and a few years later the question of the Nottingham Plant was again revived. The first land for Nottingham was purchased in 1935 and the last in 1937. The entire plant site includes approximately 77 acres.

The Nottingham Filtration Plant site lies in an area bounded by St. Clair Avenue, Nickel Plate Railroad, Nottingham Road and Chardon Road. It is about 1½ mi. from the lake and about 6½ mi. northeast from the Baldwin Filtration Plant. The plant will have a total capacity of 200 mil.gal., half of which will be built as the first unit. Water will be supplied to the plant directly through a 9-ft. tunnel, the length of which, including the land portion, will be about 6 mi.

Beginning in 1935, the Nottingham site was stripped of its trees and underbrush. In the same year a start was made toward shifting Euclid Creek (which meandered across the property) next to the high bank, at the westerly limits of the site. Most of this work was carried out by WPA. In the same manner, over a period of years, the rough excavation for the filtered water reservoir (50-mil.gal. capacity), the filters and administration building and the settling basins was carried out. In addition, finished excavation was made for the screen well and low-lift pump room and for a part of the filtered water conduit and main drain. Where such excavation was made these structures were partly completed. About 1000 ft. of the main drain has been completed and nearly 1650 ft. of filtered water conduit.

Screen Well and Low-Lift Pump Room: In making the excavation for the filtered water conduit and main drain, a considerable amount of water was encountered. It was, therefore, reasonable to assume that the screen well and low-lift pump room located near these structures and with the bottom grade from 50 ft. to 60 ft. lower would be subject to considerable hydrostatic pressure. The screen well and low-lift pump room were designed with that idea in view. During construction only a relatively small quantity of water was actually encountered. This, however, does not preclude the possibility of considerable quantities reaching the structure during flood stages of Euclid Creek, which is located about 300 ft. away.

The Nottingham Screen Well and Low-Lift Pump Room (Fig. 6) consists of two heavily reinforced concrete hollow cylinders built eccentrically within one another and tied together by reinforced concrete ties and diaphragms. These cylinders extend for a height of 48 ft. above the foundation, with the outer cylinder continuing for another 40 ft. up to the motor floor. The outside diameter of the larger cylinder is 106 ft. and that of the smaller, 64 ft. The tunnel from the lake is connected to the other cylinder and the space between the two cylinders is the waterway from which the low-lift pumps take their suction. This waterway varies in width from 7½ ft. to 21½ ft., with the greater width in that section where the tunnel enters. The low-lift pumps are located within the smaller hollow cylinder.

Provisions have been made for removable screens near the tunnel entrance and for two 7×9-ft. sluice gates at the tunnel entrance to keep the water from the lake entirely out of the screen well when desired. A solid wall, extending across the wide section of the waterway, has been provided between the two sluice gates. At the opposite end of the diameter passing through this wall, another wall has

been provided across the narrow section of the waterway. Provisions have been made in this wall for a 5 × 8-ft. sluice gate. These arrangements permit the use of half the screen well while the other half is out of service. Proper drainage and overflow have been provided and the effect of surge considered.

It is contemplated that motor-operated vertical pumps will be used, with the motors placed on the floor at an elevation of plus 40 ft., with the center-line of the pumps at an elevation of minus 15 ft. Provisions will be made for both stairs and elevator in the pump section.

Filtered Water Reservoir: Although the prime need contemplated in connection with the Nottingham Filtration Plant and Pumping Station was to supply the vast second high-service district east of the Cuyahoga River, the first actual use of the plant will be in connection with the easterly end of the East Side low-service district. The increased need for water for this section, the fact that it is furnished by a gravity supply with a fixed maximum elevation and its considerable distance

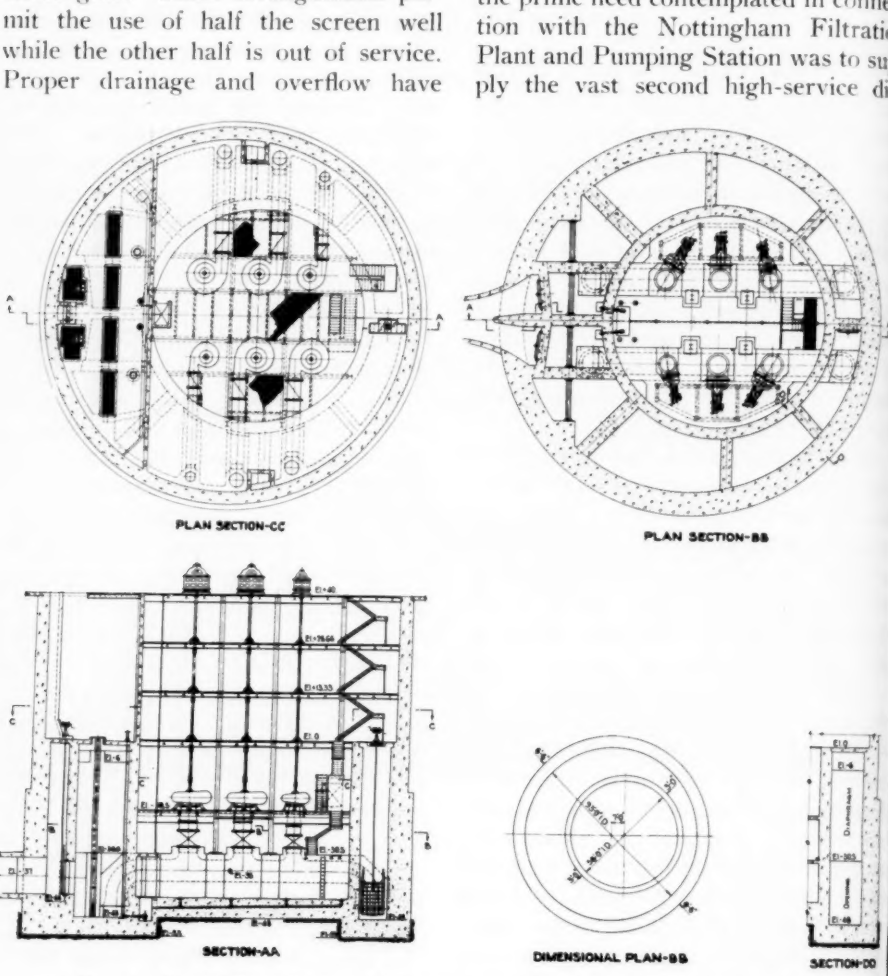


FIG. 6. Nottingham Screen Well and Low-Lift Pump Room, Cleveland

from Baldwin Reservoir all combine to make some action necessary to meet peak demands.

The first step in this direction was taken when a 2-mil.gal. steel tank and a small electrically operated pumping station in connection with it was built in 1931. This tank was filled from the low-service system during the night and the water in the tank pumped back into the same system during the day, as required. Pressure-reducing valves permitting flow from the first high-service into the low-service district constitute another means of supplying the deficiency; and the filling of the 2-mil.gal. tank at night from the first high-service district, instead of from the low-service, was a third. A fourth means is the extension of the large mains leading from Baldwin Reservoir by building approximately 2 mi. of 48-in. mains and 1½ mi. of 24-in. mains and the fifth means is to build half of the Nottingham filtered water reservoir and an electrically operated pumping station.

The half of the Nottingham filtered water reservoir yet to be built will be about 300 ft. × 500 ft. in plan and will have a maximum depth of water of about 20 ft. It will be of concrete construction, either mass concrete with groined arch roof or reinforced concrete with a flat slab roof, depending upon the availability of reinforcing steel at the time. Means will be provided for the water to enter at one side of the basin and to be taken out at the opposite side.

An inlet gatehouse will be provided to control the water from the filters and an outlet gatehouse will tie in with the end of the existing filtered-water conduit to convey the water to the high-service pumps in the finished Nottingham Pumping Station. Temporary means will also be provided to permit flow into the reservoir during periods of low demand, from the 48-in. main now under construction, and of pumping out of the reservoir into this same main during periods of high demand. The 25 mil.gal. of water which can be stored in this reservoir, as the occasion permits, will provide a source of supply, in conjunction with some flow from Baldwin Reservoir to this section, which will meet contemplated requirements for probably the next eight to ten years.

5. Warrensville Reservoir

The existing Warrensville Reservoir is an open reservoir with paved earth embankments and paved bottom and has a capacity of about 22 mil.gal. It is located in the East Side third high-service area about 8½ mi. south of the Nottingham Filtration Plant and Pumping Station and 5½ mi. southeast of the Baldwin Filtration Plant and Fairmount Pumping Station. The entire new Warrensville Reservoir will occupy the site of the old one and the area adjacent to it.

Warrensville Reservoir will have a capacity of 80 mil.gal. Only half of the reservoir will be built in the near future. This part will be a flat slab concrete covered reservoir about 450 ft. × 541 ft. in plan, with the roof 11½ in. thick, except at the columns. The floor will be 18 in. thick, reinforced top and bottom, and the columns will rest on the floor. Columns, in general, are to be 27 in. in diameter on 20-ft. and 24-ft. centers. Double columns will be provided at all roof expansion joints. Walls will be of the cantilever type. The maximum depth of water will be 27½ ft. There will be an earth embankment around the concrete walls and an earth fill over the roof. Large sup-

ply mains will radiate from the reservoir.

The rough excavation for the one basin, together with about 700 ft. of concrete conduit and 400 ft. of corrugated-iron culvert built for drainage purposes, was completed in November 1937.

6. Supply Mains

To put into operation the Baldwin-Fairmount Project and Parma Reservoir and to keep pace with the expanding areas supplied with water, as well as to meet the increasing demands in the territories already supplied, or partly supplied, while keeping in mind the ultimate use in the general plan to which some of these mains will be put, it has been necessary, during the past quarter of a century, for the City of Cleveland to spend approximately $8,000,000 on supply mains, between 20 in. and 54 in. in diameter. A total of nearly 100 mi. of such mains has been constructed during this period. These mains are in addition to the 60-in. transmission mains previously enumerated, and to the miles of subfeeder mains, 12 in. and 16 in. in diameter, constructed by the city within city limits, by the suburbs within their own municipalities and by Cuyahoga County within the county sewer districts.

Twenty-five years ago practically all supply mains in the Cleveland area were cast iron. In about 1924 the use of steel for large mains was initiated and since that time most of the supply mains have been of that material. Some two years ago, reinforced concrete mains came into competition with steel and about 7 mi. of such mains have been, or are being, laid.

Progress in Pumps and Pumping Stations—S. C. Simmermacher

A BARE description of the changes in Cleveland's pumping facilities since 1921 would not leave a very clear picture, so the author has attempted to present these data in detail in tabular form. Thus Tables 1 through 4 have been prepared to show the plants and units in service in 1921 and all additions and removals since that time. Table 5 is given as a summary of the plant capacities in 1921 and in 1943.

In 1920 a long-range expansion program was developed specifically to cover greater Cleveland's requirements up to 1940 and to provide for additional facilities as needed thereafter. This program included the following projects for additional pumping facilities:

1. Increasing Kirtland Station's capacity from 130 to 200 mgd.
2. Constructing a completely new pumping station of considerably increased capacity to replace the Fairmount Plant
3. Constructing a new plant to pump water from the lake at the eastern extremity of the city—the plant to have an ultimate capacity of 165 mgd. with 75 mgd. in service by 1940
4. Constructing a similar plant at the western extremity of the city.

Of this program only the first two items have been substantially completed. An entirely new plant has been constructed to replace the old Fairmount Pumping Station and one additional unit has been installed at Kirt-

land Station bringing its capacity up to 190 mgd.

Construction of Fairmount Station was completed and the plant put in operation in 1923. It was not fully utilized, however, until completion of the Baldwin Filtration Plant in 1925. At that time Kirtland Station ceased pumping unfiltered water into the low-service districts. Its entire pumpage

TABLE 1

Equipment in Main Steam-Driven Pumping Stations

Station	No. of Units	Type	Unit Capac.	Service	Pump Net Head	Date Installed	Date Removed	Remarks
			mgd.		*ft.*			
Division *	1	Triple-expansion pump engine	20	low	202	1898	—	Rebuilt in 1916
	1	Triple-expansion pump engine	20	low	199	1902	—	Rebuilt in 1916
	2	Triple-expansion pump engine	25	low	250	1916	—	
	1	Triple-expansion pump engine	10	1st high	405	1902	—	Rebuilt in 1916
	1	Triple-expansion pump engine	20	1st high	380	1916	—	
	1	Geared turbine-driven centrifugal	20	1st high	400	1920	—	
	1	Geared turbine-driven centrifugal	60	low-lift	50	1916	—	
	2	Geared turbine-driven centrifugal	100	low-lift	50	1916	—	
Kirtland †	2	Triple-expansion pump engine	25	low	190	1903	—	Changed to Fairmount raw water supply in 1925
	2	Triple-expansion pump engine	25	low	250	1912	—	
	1	Geared turbine-driven centrifugal	30	low	250	1914	—	
	1	Geared turbine-driven centrifugal	60	Fairmount raw water	270	1926	—	
Fairmount (Old) ‡	1	Horizontal duplex	10	1st high	200	1906	1924	Moved from Division
	1	Geared turbine-driven centrifugal	12 or 5	1st high / 2nd high	185 / 444	1914	1924	
	2	Triple-expansion pump engine	2	2nd high	400	1907	1924	
	1	Turbine-driven centrifugal	5	2nd high	450	1919	1924	
	1	Motor-driven centrifugal	4.68	1st high	175	1923	1924	Temporary installation
	1	Motor-driven centrifugal	10 or 5	1st high / 2nd high	225 / 450	1923	1924	Temporary installation
Fairmount (New) §	2	Geared turbine-driven centrifugal	75	low-lift	80	1924	—	
	1	Geared turbine-driven centrifugal	50	low-lift	80	1924	—	
	2	Geared turbine-driven centrifugal	20	1st high	135	1924	—	
	3	Geared turbine-driven centrifugal	20	2nd high	400	1924	—	

* Boiler plant: Six 500-boiler-hp. "Stirling" type boilers, fired with six retort underfed stokers; designed for 250 psi. W.S.P. (working steam pressure) and 100°F. superheat.

† Boiler plant 1921: Eight 300-boiler-hp. straight-tube boilers, fired with chain grate stokers; designed for 150 psi. W.S.P. and 150°F. superheat; removed in 1928. Boiler plant 1943: Four 700-boiler-hp. "Stirling" type boilers, fired with seven retort underfeed stokers; designed for 250 psi. W.S.P. and 150°F. superheat.

‡ Boiler plant: One 500-boiler-hp. "Stirling" type, one 500- and one 130-boiler-hp. straight-tube boilers, all with chain grate stokers; designed for 200 psi. W.S.P.

§ Boiler plant: Four 1000-boiler-hp. "Stirling" type boilers, with ten retort underfeed stokers; designed for 320 psi. W.S.P. and 150–200°F. superheat.

since that time has been discharged into an open reservoir 170 ft. above the lake and adjacent to Fairmount Station. Fairmount low-lift pumps repump the unfiltered water to the Baldwin Filtration Plant. After filtration, part of the water flows by gravity into the low-service district area formerly supplied by Kirtland Station and part of it returns to Fairmount Station to be repumped to the first and second high-service districts.

TABLE 2

Equipment in Secondary Motor-Driven Pumping Stations

Station	No. of Units	Type	Unit Capac.	Service	Pump Net Head	Date Installed	Date Removed	Remarks
			mgd.		*ft.*			
Kinsman	1	Motor-driven centrifugal	5.0	2nd high	300	1921	1931	
	1	Motor-driven centrifugal	5.47	2nd high	300	1924	1937	Moved to Parma
Merkle *	2	Motor-driven centrifugal	2.0	2nd high	335	1921	1939	Moved to Parma
Parma	1	Motor-driven centrifugal	5.47	2nd high	300	1939	—	From Kinsman
	1	Motor-driven centrifugal	2.0	2nd high	335	1939	—	From Merkle
	1	Motor-driven centrifugal	2.0	2nd high	335	1940	—	From Merkle
Warrensville	1	Motor-driven centrifugal	0.7	3rd high	250	1916	1936	
	1	—	0.7	3rd high	250	1921	—	
	1	Gasoline-engine-driven centrifugal	0.7	3rd high	250	1924	—	
	1	Motor-driven centrifugal	1.08	3rd high	250	1932	—	
	1	Motor-driven centrifugal	2.9	3rd high	250	1937	—	From Beachwood

* Acquired from county in 1932.

TABLE 3

Equipment in Pressure-Tank Stations

Station	No. of Units	Type	Unit Capac.	Service	Pump Net Head	Date Installed	Date Removed	Remarks
			mgd.		*ft.*			
Chardon *	1	Motor-driven centrifugal	0.43	1st high		1926	—	
	1	Motor-driven centrifugal	1.44 1.3	1st high	205 270	1926 1933	1933	Pump end replaced in 193
	1	Motor-driven centrifugal	0.36	1st high	250	1932	—	
State Road †	2	Motor-driven centrifugal	0.72	3rd high	270	1922	—	
Mayfield †	2	Motor-driven centrifugal	0.43	3rd high	100	1924	—	
Beachwood ‡	2	Motor-driven centrifugal	0.36	3rd high	250	1927	1932	
	1	Motor-driven centrifugal	1.08	3rd high	250	1930	1932	

* Acquired from City of Euclid in 1932.
† Acquired from county in 1932.
‡ Acquired from Beachwood Village in 1932.

The plant has eight main units all manufactured by the De Laval Steam Turbine Co. Two low-lift pumps of 75-mgd. capacity each and one of 50-mgd. pump water from the Fairmount Reservoir to the Baldwin Filtration Plant. Two first high-service and three second high-service pumps, all of 20-mgd. capacity, re-pump filtered water into the higher districts.

The new station has four Babcock and Wilcox "Stirling" type boilers designed for a 320-psi. working steam pressure and 150 deg. of superheat. The plant also supplies a district heating system with 100,000 lb. of steam

TABLE 4

Equipment in Temporary Motor-Driven Pressure Booster Plants

Station	No. of Units	Type	Unit Capac.	Service	Pump Net Head	Date Installed	Date Removed	Remarks
			mgd.		*ft.*			
St. Clair	1	Motor-driven centrifugal	2.38	low	135	1931		From Kinsman
Euclid	1	Motor-driven centrifugal	0.5	1st high	250	1932		From Beachwood
Garfield	1	Motor-driven centrifugal	4.7	2nd high	175	1932		From Fairmount

TABLE 5

Plant Capacities, in mgd.—1921 and 1943

Year	Plant	Lake Pumpage	Low Lift	Low Service	1st High	2nd High	3rd High
1921	Division	260		90	50		
	Kirtland			130			
	Fairmount				22	14	
	Kinsman					5	
	Merkle					4	
	Warrensville						1.4
1943	Division	260		90	50		
	Kirtland	190*					
	Fairmount		200		40	60	
	Kinsman						
	Merkle						
	Parma					9	
	Warrensville						5.38
	Chardon				2.09		
	State Road						1.44
	Mayfield						.86
	St. Clair			2.38			
	Euclid				0.5		
	Garfield					4.7	

* Repumped by Fairmount Low-Lift.

extracted from the main turbines, at pressures of 75 to 125 psi.

The other major change was the addition of one large turbine-driven centrifugal pump at Kirtland Station. A new screen well, suction tunnel, discharge header and building were constructed to house and accommodate three turbine-driven centrifugal pumps. Only one of the pumps has been installed. It, as well as the thirteen other main turbine-driven units, is a De Laval product, having a capacity of 60 mgd. against a total head of 270 ft. and a duty which compares very favorably with triple-expansion pumping engines. No attempt has ever been made to establish a record with this unit, but it has given remarkable service. In checking over pumping reports, it has been found that this unit, after eight years of service, was operated for a period of one year and 24 days continuously. During this run it pumped 22,080,835,000 gal. of water. Eight old 300-hp., 150-psi. pressure straight-tube boilers were replaced at Kirtland Station, at the same time, by four 700-hp. Babcock & Wilcox "Stirlings" designed for 250 psi. and 150 deg. of superheat. Higher pressures and temperatures were not used because of the limitations of other equipment.

The other two proposed plants were not constructed because Cleveland's growth in the two decades following 1920 did not follow the previous trend. Both the population and total water demand leveled off. People did move into the suburbs, however, and numerous critical pressure areas developed. To give some measure of relief, a number of temporary electric-motor-drive plants have been constructed. Those in year-round service are semi-automatic, some pumping into reservoirs or elevated tanks, others maintaining pressure by the use of compressed air in closed pressure tanks adjacent to the pumps.

Several other manually operated units have been installed for use only in the hot summer months. These store water in steel storage tanks on cool days and in off-peak hours and pump back into the same service during the peak demand hours of the day. Permanent relief for areas served by these small units can be obtained only after the proposed plants at the eastern and western extremities of the city are constructed. Unfortunately, many war plants have been constructed with little regard for water problems and have been located in the worst pressure areas. If the 1920 program had been carried out, the city would now have a capacity of 450 instead of 300 mgd. and would be able to supply the war plants and outlying areas adequately. In 1941, peak demand of 265 mgd. was reached. Although the 1942 average consumption showed a considerable increase, peaks were not so severe.

This year the department has an accumulation of troubles, including slow replacement of worn parts, large labor turnover and poor coal. These troubles, coupled with a hot dry summer and the wartime industrial activity, will necessitate curtailment of water supplied for less essential uses

The Baldwin Filtration Plant—L. A. Marshall

AS pointed out in the first section of this paper, the Baldwin Filtration Plant has been one of the largest improvement projects undertaken in the last 25 years of Cleveland's water supply history. Herewith is presented a detailed description of the plant together with summary tables of the major operating data (Tables 6–9).

It will be noted that Table 6 gives a comparative record of general statistics on the Baldwin and Division Avenue Plants. Since the development of the Division Avenue Plant, discussed briefly in the first section of this paper, antedates the quarter-century period covered by this report, it is not described in detail here.*

Following, then, is a description of the Baldwin Plant, discussing, in turn, the various features shown in the accompanying flow diagram (Fig. 7).

Hydraulic-Jump Section

After passing from two 60-in. mains and through two 60 × 30-in. Venturi meter tubes, raw water enters the Baldwin Filtration Plant by means of a rising well (el. 245.74 ft. above city datum) which extends across the entire width of the chemical house. Flowing from an upper pool, the raw water then passes through three hydraulic-jump mixing flumes. These flumes have expanding sides and sloping bottoms and are preceded by horizontal throats of constant width with curved entrances. At the foot of the slopes they lead into a converging horizontal flume. Provisions were made in each throat for a double row of stop-planks to cut off the flow of water through the flume, if desired. The flumes are housed in a one-story building, in which walkways conveniently located permit an adequate view of the hydraulic jumps.

Just beyond the weir planks for controlling the tailwater depth, the converging shallow flume is transformed into a conduit section. This is accomplished by dropping the floor about 9 ft. and narrowing the sides, thus producing a conduit section about 19 ft. wide and 13 ft. deep, leading to Gatehouse 1. This conduit section, which is about 90 ft. long, is equipped with a pair of under-and-over baffles near each end.

Settling Basins

Leading from Gatehouse 1, an inlet conduit forming the south wall of four settling basins supplies the waterway through which the water flows to Gatehouses 2 and 3. The former controls the flow to Basins 1 and 2, and the latter to Basins 3 and 4, through one 60 × 84-in. sluice gate for each basin. The control from the settling basins at the outlet end is effected through Gatehouse 5 for Basins 1 and 2 and through Gatehouse 4 for Basins 3 and 4. At the outlet end there is also one 60 × 84-in. sluice gate for each basin. Provision was made for bypassing the settling basins through a conduit along the west side of the basins, connecting Gatehouses 1 and 6. The bypass control is effected through these gate-

*A detailed description of the Division Avenue Plant was given in the paper entitled "Cleveland Water System," by G. E. Flower (Jour. A.W.W.A., **9**: 418 (1922).

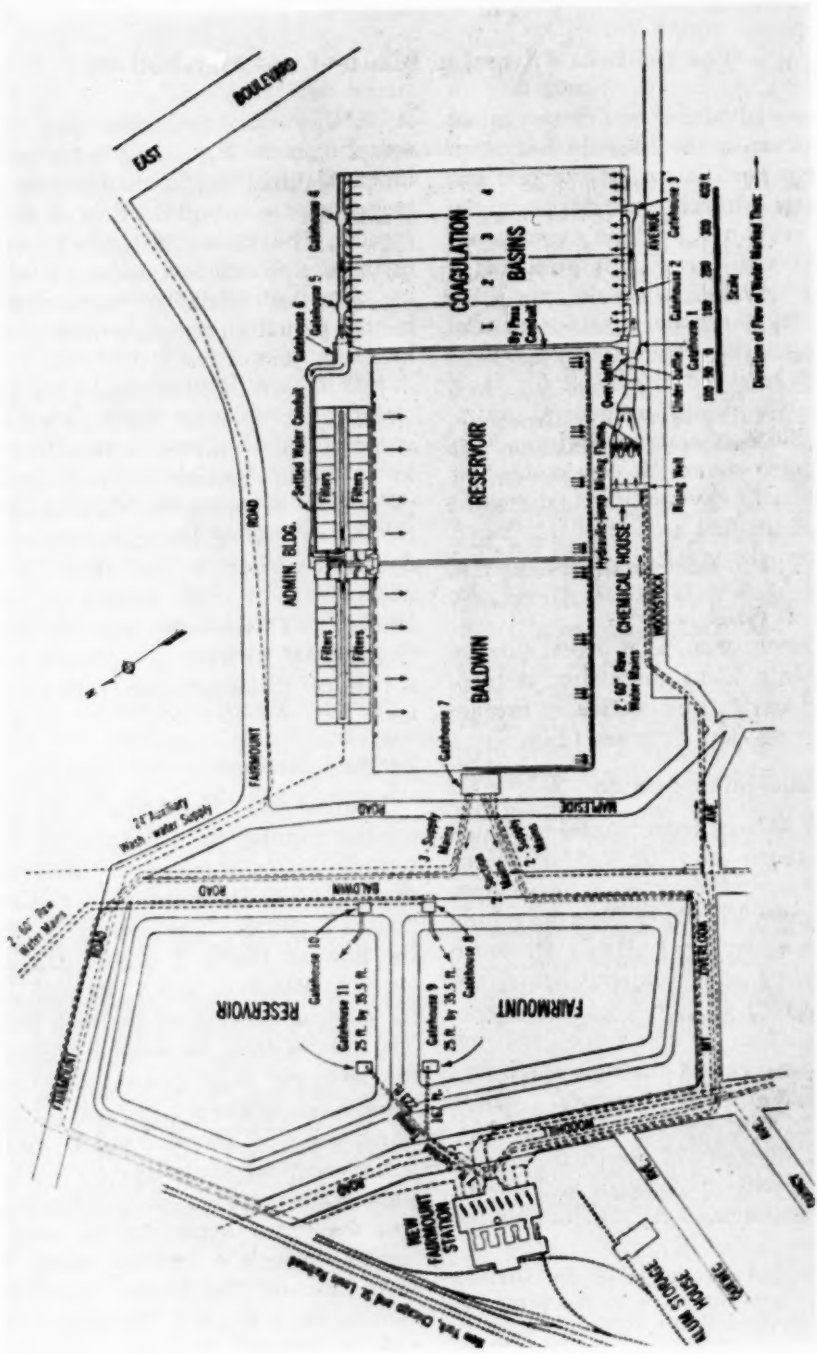


FIG. 7. General Arrangement of Structures and Direction of Flow of Water—Baldwin Filtration Plant

TABLE 6

Comparative Data on Baldwin and Division Avenue Filtration Plants

Item	*Division*	*Baldwin*
Date of beginning operation	1918	1925
Nominal capac., *mgd*	150	165
Area of site, *acres*	20	50*
Cost, *dollars*	3,497,000	7,510,000†
Anal. of raw water (1938–42):		
Turb. range, *ppm*	0.2–200	0.2–165
Turb. avg., *ppm*	9.5	8.5
Alk. avg., *ppm*	93	93
pH, avg	8.1	8.2
Mixing chambers:		
Type of chem. feed	Soln.	Soln.
Alum added, *lb. per mil.gal.*	70–350	70–350
Type of mixing	Baffles	Hydr. Jump
Type of baffling	—‡	—§
Time of mixing, *min.*	39	1‖
Veloc. flow in channels, *fpm.*	21	600–700¶
Veloc. flow at baffles, *fps.*	1	2.3
Length of travel, *ft.*	820	30**
Head loss in mixing, *ft.*	1.5	2.4
Settling basins:		
Avg. turb. settled water, (1938–42), *ppm*	1.6	1.4
Number of basins	6	4
Type of baffling	Around-end	None
Settling time at nominal capac., *hr.*	3.4	4.67
Veloc. flow, *fpm*	2.8	2.4
Length of travel, *ft.*	683	693
Total basin capac., *mil.gal.*	21	32.8
Open or covered	Cov.	Cov.
Settled water conduits:		
Veloc., filter influent mains, *fps.*	2.2	2.17
Veloc., filter inlets, *fps.*	2.94	2.04
Filters:		
Rate of filtration, *mgad.*	125	125
Number of units	—	40
Filtering capac. each unit.	4.16	4.16
Area of sand, *sq.ft.*	1450	1450
Filters (*Continued*):		
Thickness of sand, *in.*	24–27	25.5
Effective size of sand, *mm.*	0.48	0.38
Uniformity coef. of sand	1.50	1.70
Thickness of gravel, *in.*	22–25	22
Max. size of gravel, *in.*	1½	1½
Min. size of gravel, *in.*	⅛	⅛
Distance, top of sand to crest of trough, *in.*	26–30	30
Clear distance between troughs, *ft.*	6.0	4.93
Type of strainer system	Central manifold and perf. pipe laterals	
Location of wash gullet	Center	Center
Rate of wash, *in. rise per min.*	24–29	24–36
Avg. percentage wash water (1938–42)	2.81	2.55
Agitation of sand	No	No
Wash-water tank capac., *1000 gal.*	4.60	2 @ 212
Filtered water reservoir:		
Open or covered	Cov.	Cov.
Capac., *mil.gal.*	20	135
Chlorine feeding equip. capac.:		
Pre-chlorination, *lb. per 24 hr.*	4000	4000
Post-chlorination, *lb. per 24 hr.*	3800	3350
Ammonia feeding equip. capac.:		
Pre-ammoniation, *lb. per 24 hr.*	900	900
Post-ammoniation, *lb. per 24 hr.*	900	900
Powdered activated carbon feeding equip., *lb. per 24 hr.*	240–24,000	240–24,000

* Including Baldwin Reservoir.
† Filter plant only.
‡ Over-and-under and around-end—as now arranged with 12 pairs of baffles in first channel and one each in the remaining five. There are 4 mixing chambers.
§ Two pairs over-and-under baffles in channel beyond mixing flume.
‖ In hydraulic jump.
¶ Velocity through hydraulic-jump flume only.
** Length of hydraulic-jump flume is 30 ft. and from rising well to Gatehouse 1 is 325 ft.

FIG. 7. General Arrangement of Structures and Direction of Flow of Water—Baldwin Filtration Plant

houses, where the water may be shut off entirely from the north and south conduits. When the bypass is in use, all the water flows through two 60 × 84-in. sluice gates in each of the gatehouses. Under conditions of maximum flow, a velocity of about $3\frac{3}{4}$ fps. would result through these gates.

The four settling basins have an average depth of 15 ft., varying from a minimum of 9 ft. 4 in. to a maximum of 18 ft. 6 in. The water enters at one end of each basin over a weir and under a stilling baffle, and is taken off at the opposite end over a similar weir. The basins are of reinforced concrete construction with groined arch roofs and reinforced sloping floors. The sloping floors perform the dual function of facilitating cleaning and of reducing the height of the wall sections. Each settling basin is equipped with six mud valves for draining and cleaning. These valves permit flow into a lateral drain placed immediately under the floor of the basin and along the longitudinal axis. Each drain is connected to the main drain header near the north end of the basins. To assist in cleaning, $2\frac{1}{2}$-in. hose gates spaced about 50 ft. from center to center are provided on each side of each basin, these gates being connected to 6-in. mains placed on the long walls of the basins.

TABLE 7

Chemical Feeds Used and Residual Chlorine Found in the Finished Water—Baldwin Filtration Plant—1926–42

Year	Chemicals Fed, *lb. per mil.gal.*						Residual Chlorine, *ppm.*
	Alum	Chlorine		Ammonia		Carbon	
		Pre-	Post-	Pre-	Post-		
1926	132	—	2.75	—	—	—	0.054
1927	148	—	2.83	—	—	—	0.063
1928	126	—	2.75	—	—	—	0.054
1929	130	—	3.75	—	—	—	0.060
1930	123	—	3.67	—	0.92	—	0.277
1931	119	—	3.83	—	1.17	—	0.32
1932	108	2.33	3.25	0.67	0.83	—	0.22
1933	120	2.25	2.58	0.75	1.00	—	0.23
1934	115	1.75	3.00	0.58	1.00	—	0.31
1935	115	1.08	3.08	—	1.08	—	0.32
1936	113	1.50	3.08	0.67	1.00	—	0.31
1937	115	3.00	3.42	—	1.00	—	0.34
1938	92	3.50	3.42	0.25	1.00	—	0.34
1939	88	3.92	4.58	—	1.42	3.5	0.49
1940	109	3.83	4.92	1.21	1.75	26.4	0.42
1941	92	3.57	5.49	1.75	1.52	5.6	0.56
1942	116	6.64	5.30	1.52	1.68	10.17	0.47

Settled Water Conduit

Water is conveyed from the settling basins through a concrete conduit 8 ft. wide by 13 ft. 5 in. high, north of and adjacent to the east wing of the filter building. This conduit terminates in a section 14 ft. 5 in. wide by 13 ft. 3 in. high just inside the Administration Building. This latter conduit is connected to the conduit that runs the

length of the pipe galleries by means of a short section of double-barreled conduit. Within the pipe gallery, the conduit is 7 ft. wide by 8 ft. high and in the Administration Building it is 11 ft. 3 in. wide by 5 ft. high. The conduits within the pipe galleries are connected to the one in the Administration Building by transition sections.

TABLE 8

Coliform Indices—Baldwin Filtration Plant—1926–42

Sample	1926	1927	1928	1929	1930	1931	1932	1933	1934	1925	1936	1937	1938	1939	1940	1941	1942
Lake Water	844.1	267.7	162.8	376.9	421.8	1225.3	167.0	73.7	109.3	202.2	102.5	283.1	117.7	89.9	132.2	50.8	96.5
Plain Settled Water-Rising Well	576.8	219.0	118.9	383.5	659.7	961.1	183.0	106.3	73.1	139.3	95.1	239.3	142.9	59.0	134.5	62.2	148.5
Coagulated Settled Water Applied to Filters	208.1	41.6	25.6	102.8	125.2	222.3	13.2	1.4	1.2	29.8	0.86	3.2	0.67	5.3	1.7	0.46	0.04
Filtered Water	13.6	11.3	6.8	23.9	26.9	19.7	3.1	3.3	12.1	10.5	10.9	24.4	4.2	3.1	2.6	0.38	0.00
Disinfected Filtered Water	0.2	0.3	0.01	0.039	0.13	0.06	0.01	0.0	0.0	0.0	0.0	0.0	0.14	0.0	0.1	0.0	0.00
Percentage Removal	99.9	99.8	99.9	99.9	99.9	99.9	99.9	100	100	100	100	100	99.9	100	99.9	100	100

Filter Tanks

The filter tanks are housed in the two wings of the Administration and Filter Building. These wings are each approximately 360 ft. long by 130 ft. wide and extend at right angles to the major axis of the Administration Building. The 40 filter tank units are ranged in a double row on either side of a central operating and pipe gallery. Settled water enters them through 24-in. cast-iron branch connections to the concrete settled water conduit. Each filter tank has a sand area of 1450 sq.ft., divided into two equal areas by a center gutter, with steel wash-water troughs running at right angles to the center gutter, the slope of the bottoms of which is 1 in. in the full length of the troughs. The strainer system of the filter tanks is of the perforated pipe manifold type, with the manifold located under the central axis of the sand layer in each half of the filter. The manifolds for each half filter consist of four independent castings, each having a central source of water supply. Each of the manifold castings supplies 42 cast-iron laterals. In order to wash the otherwise dead area over the manifold, $\frac{3}{8}$-in. brass umbrella-type strainer

TABLE 9

Typhoid Death Rate per 100,000 Population—Cleveland—1880–1942

Year	Death Rate	Remarks
1880	99	
1890	75	
1900	110	
1905	14.9	New 4.5-mi. raw water intake put into service.
1910	18.7	
1912	6.2	Disinfection with calcium hypochlorite started Sept. 11, 1911.
1917	6.1	Division Avenue Filtration Plant in operation Mar. 17, 1918; 60% of population served with filtered water.
1920	3.0	
1925	1.5	Baldwin Filtration Plant in operation in October, 1925; 100% of population served with filtered water.
1935	0.6	
1942	0.2	

nozzles were provided, one nozzle serving approximately 52 sq.in. of sand area over the manifold. The total area of the holes in the strainer system is 0.309 per cent of the area of the sand layer. The area of the holes in one lateral is 36 per cent of the cross-sectional area of the lateral and the area of the laterals fed by one manifold is 71.4 per cent of the cross-sectional area of the manifold. The effective length of the lateral is 29.5 times its diameter.

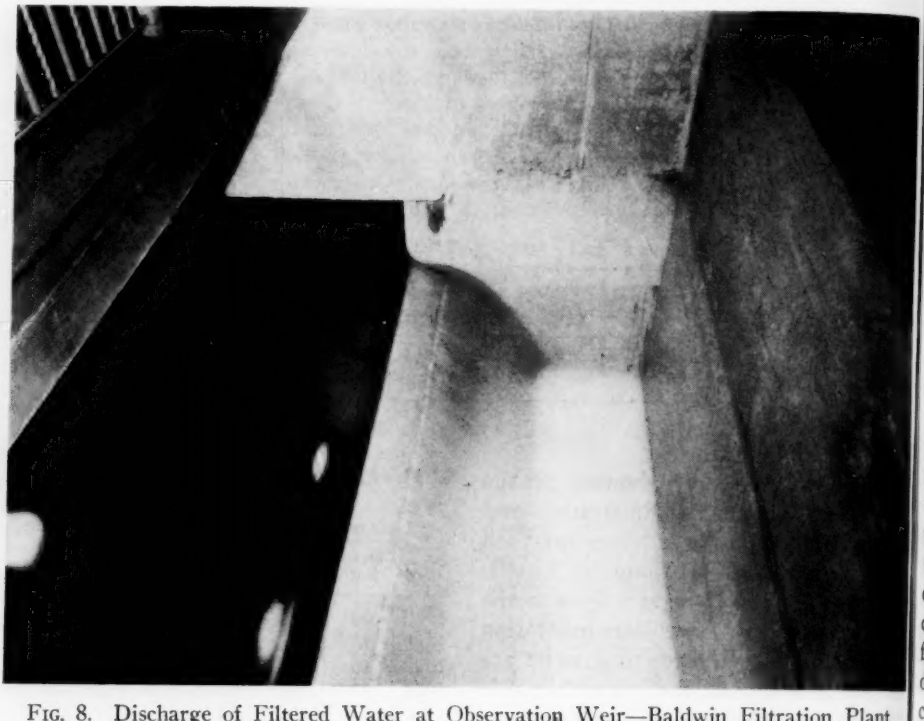


FIG. 8. Discharge of Filtered Water at Observation Weir—Baldwin Filtration Plant

Filter Effluent Galleries

From the strainer systems, the filtered water passes through rate controllers into four filter effluent galleries, each being 352 ft. 6 in. long and each being located below and serving a group of 10 filters. The two north galleries are each 47 ft. 6 in. wide and the south galleries, 45 ft. 3 in. wide. The distance from the floor to the underside of the roof is 13 ft. 3 in. and the capacity of the four galleries is about 6 mil.gal. Each gallery is provided with two 12-in. drains which empty into the main drain, each being provided with two valves in series. A 24-in. flanged access manhole was provided in the common wall between the effluent and pipe galleries at about the mid-point in the length of the wall. At the ends of the galleries, next to the Administration Building, sight wells, 4 × 5 ft. in plan, open into the effluent galleries. They permit observation of the filtered water during operation and provide means of taking out any of the piping in the effluent galleries in the event that such a need should arise. The piping

in the effluent galleries, in conjunction with the strainer systems, acts as the collecting systems for the filtered water, conveying it from the filters through the controllers in the pipe gallery and then back again into the open effluent gallery. The same system of piping in the effluent galleries serves for the distribution of the wash water during the washing process.

Filtered Water Conduit

Along the north and south centerline of the Administration Building and resting upon the basement floor is a reinforced concrete conduit for conveying the filtered water from the effluent galleries to the filtered-water reservoir. From the end of the conduit nearest the settled water conduit, a 54-in. bypass is connected to the latter. This bypass is controlled by two 48-in. valves, which are arranged with a spacer piece between them. A 2-in. open drain in the bottom of the spacer piece guards against the slightest possibility of contamination of the filtered water by the settled water. The filtered-water conduit is connected to the four filtered-water effluent galleries under the filters by 54-in. cast-iron pipe, controlled by 48-in. valves. At the filtered-water reservoir end of the conduit, connection is made to the inlet control works of this reservoir. The control works contain four 60 × 84-in. sluice gates, arranged in pairs, for controlling the flow of water to either or both of the two basins of the filtered-water reservoir.

Hydraulic Data

With normal operating levels in the settling basins, the computed velocity in the channel leading from the hydraulic-jump mixing flumes to Gatehouse 1 varies from 0.76 to 1.20 fps., except at the under and over baffles where a velocity of 2.53 fps. is reached. In the influent conduit of the settling basins the computed velocity of the water is 2.17 fps. and in the effluent conduit 2.42 fps., the latter being also approximately the maximum velocity through any of the sluice gates. The flow through the settling basins is at a computed rate of 2.36 fpm., through the settled-water conduit, 2.37 fps. and through the settled-water piping leading to the filters, 2.04 fps.

The computed loss of head in feet through the filter plant, together with the actual losses obtained as the result of a series of observations made when the plant was operating at the nominal rated capacity of 165 mgd., with water at normal operating level in the settling basins, are given below:

	Computed	*Observed*
Loss through hydraulic-jump mixing flumes	2.04	2.40
Loss from tail-water of jump to Gatehouse 1	0.97	0.88
Loss from Gatehouse 1 to settling basins	0.56	0.30
Loss from basins to filters	1.25	0.93
Total loss to filters	4.82	4.51
Head available for filter operation with water at normal operating level in Baldwin Reservoir	11.75	—
Loss from filter effluent galleries to inlet flumes in Baldwin Reservoir, with water falling freely over the fixed weirs	1.00	0.81

Wash-Water Tanks

Two wash-water tanks are located on steel grillage in the upper part of the Administration Building, with the bottoms of the tanks about 44 ft. above the maximum height of the wash-water troughs in the filters. These tanks are of steel-plate construction, each 60 ft. in diameter and 12 ft. deep, and are

intended to operate with a maximum of 10 ft. of water. At this depth the capacity of the two tanks is 423,000 gal. A 36-in. cast-iron pipe leads from the bottom of each tank into a header which discharges into a 42-in. vertical pipeline leading to the basement, where it joins the 30-in. wash-water line in the pipe galleries. The pipe from each tank is provided with a 36-in. valve for controlling the flow.

A 16-in. cast-iron overflow is installed in each tank, the entrance to this overflow being over a bellmouth piece with its weir edge placed 10 ft. 3 in. above the bottom of the tank. In order to reduce the tendency to suck air, caused by vortex action under low-water conditions, an inverted steel cone, 3 ft. 10 in. in diameter and with the sides forming an angle of 45 deg. to the base, was placed at the entrance to each 36-in. outlet. The apex of the cone is set in the plane of the bottom of the tank. In order to facilitate the maintenance of the steel tanks and the grillage, as well as to take care of condensation from the tanks, pipe, etc., a reinforced concrete floor with a proper system of drainage was placed under the tanks.

Wash-Water Line

The 30-inch wash-water line is a cast-iron bell and spigot main that runs along the east and west center-line of the Administration and Filter Building under the settled-water conduit, supported on concrete beams spanning between the columns supporting this conduit. It is connected by a cross, located near the west side of the building, to a 42-in. line from the wash-water tanks and to the 24-in. discharge from the wash-water pumps. Four valves are grouped in the immediate vicinity of this cross, one on either side of it on the 30-in. line and one on each of the 24-in. and 42-in. lines. This arrangement permits wash water to be furnished either from the tanks or from the pumps to the filters in either wing of the filter building. A manhole and drain are provided in the 30-in. wash-water line and a Venturi meter in the 24-in. pump discharge for measuring the flow of wash water from the pumps. A 30-in. cast-iron suction pipe, encased in concrete under the floor of the basement, leads to the wash-water pump room. This suction pipe is connected to sumps in the floors of two of the filter effluent galleries, each branch being provided with a 30-in. valve. At the west end of the pipe gallery, the wash-water pipeline is connected to a 24-in. service supply main, and this furnishes an additional or emergency source of wash-water supply.

The control of this supply of wash-water is by means of an altitude valve. If this valve fails to close when the wash-water tanks are full, the supply is closed by means of an electrically operated gate valve located between the altitude valve and the wash-water tanks. This emergency valve may be controlled by floats in the wash-water tanks, by a push-button switch or it may be operated manually by means of a hand-wheel. Just outside the building, located in a valve vault, are a 24-in. pressure-regulating valve, a 24-in. check valve and an 8-in. emergency connection to a higher pressure water supply main. The pressure-regulating valve is used to reduce the presure in the service main to that required in the wash-water system. The 24-in. check valve was required to prevent water from the 8-in. emergency connection from backing up into the lower pressure 24-in. service main.

Pipe or Operating Galleries

The pipe galleries are located in the filter building in the space between the two rows of filter tanks and extend vertically from the level of the effluent gallery floor to the operating floor. There are two such galleries, each having the same length as the filter effluent galleries, and each being 27 ft. wide by approximately 28 ft. high. In them are the settled-water conduit and wash-water pipe, with connecting piping for each individual filter, and the filter rate controllers. An 8-in. water-pressure line and a steam-heating line, suspended from, and approximately 3 ft. below, the operating floor, run the entire length of the two pipe galleries and across the Administration Building.

Filter Piping

The system of piping at each filter consists of a 24-in. influent line controlled by a valve of the same size, a 24-in. effluent line containing a filter rate controller and a 24-in. valve, a 24-in. wash-water line controlled by a valve of the same size, a 30-in. drain line with a 30-in. valve and an 8-in. filtered-water waste line and valve. All the valves are of the double-disk, parallel-seat type and all are hydraulically operated except the hand-operated 8-in. filtered-water waste valve. The 8-in. pressure line running longitudinally through the pipe galleries supplies water for operating the hydraulic valves. To avoid shutting down a considerable number of filter units due to a break in this line, it is fed from either end and valves are placed at quarter-points. At each end of the line, pressure-regulating valves are provided to reduce the pressure to that required for operating the hydraulic valves. The waste from all the hydraulic valves of each filter is piped to the central gutter of the particular filter to which they belong.

Main Drain

The main drain is a rectangular concrete conduit the top of which is reinforced and serves as a part of the pipe gallery floor. It is 5 ft. wide and, at the shallowest section, 5 ft. deep, and it has a slope of 0.00251 ft. per ft.

Alum Storage Building

An alum storage building is located on a railroad switch about half a mile west of the Baldwin Filtration Plant, adjacent to the Fairmount Pumping Station. The lack of railroad connection to the chemical house of the filter plant necessitated this separate storage building. The building is of reinforced concrete construction and is 51×87 ft. in plan and 43 ft. high. The storage capacity of the building is about 1000 tons. In the building are four reinforced concrete bins supported on columns which extend across the building. The entire area under the bins is used for truck runways.

To facilitate the unloading of alum from the box cars in which it is received, a power shovel or car plow, operated by a 51-hp. motor at 1200 rpm., is used. The alum received from the car passes through a chute to an apron feeder conveyor driven by a 2-hp. motor at 1200 rpm. This conveyor can deliver the alum either to a 24×20-in. rigid hammer crusher, operated by a 20-hp. motor at 900 rpm., or directly to a pivoted bucket carrier. The crusher has a capacity of 20 tons per hour, when crushing 5-in. lump alum to approximately $\frac{1}{2}$-in. pieces.

The alum is lifted to the top floor of the building by a pivoted bucket carrier traveling at the rate of 40 fpm., driven by a 5-hp. motor at 1200 rpm. The

buckets are 18 × 15 in. in size and, after moving horizontally, with their load, rise vertically to the upper floor, where they may feed any one of three 12-in. screw conveyors. These latter, each of which is 64 ft. in length, deliver the alum through gated chutes. The screw conveyors are driven through friction clutches and bevel gears by a 7.5-hp. motor at 1200 rpm.

A dust collector system and filter is provided for the collection and filtration of the dusty air produced in handling the alum. A 5-hp. motor at 1200 rpm. operates the fan used for sucking the dust-laden air from the crusher, chutes and rooms where it is produced and for forcing it through the cloth filter.

The building is provided with a platform elevator, 5 ft. square, with a capacity of 2500 lb. when moving at a speed of 150 fpm. A 13-hp. motor at 900 rpm. is used for operating the elevator.

Chemical House

With the exception of the upper story, the chemical house is of reinforced concrete construction of the beam and slab type with independent column footings. The upper story consists of brick-bearing walls with steel roof trusses. The remainder of the building proper is of the skeleton type with brick curtain-walls.

The chemical bins occupy the major portion of the structure to the west of the rising well. They consist of two separate bins with a passageway between them, the tops of the bins being situated at the general ground level. The total net capacity is about 350 tons. The westerly bin extends the full width of the building and the easterly one a little less than half this distance. They are continuous, with seven hoppers in the large bin and three in the small one. The minimum side slope is approximately 45 deg. and the bins discharge through 12 × 14-in. steel chutes equipped with single undercut gates, operated with a chain-and-link mechanism. These chutes discharge into a bucket on a small industrial or transfer car that is spotted in a common passageway beneath the bins. The cover over the alum bins forms the floor of the receiving room. In this floor there is one manhole to approximately 90 sq.ft. of horizontal bin surface.

On the upper floor of the chemical house are located the tops of six dissolving and four solution tanks. These are divided evenly into two independent groups. A system of piping conveys the solution from the solution tanks, through a control valve, to a lead-lined distributing trough immediately over the rising well. Piping is also provided to convey the solution to a point of secondary application in Gatehouse 6, which is in the outlet conduit of the coagulation basins. All chemical piping is lead-lined flanged cast iron and all valves are either acid-bronze or rubber-diaphragm chemical valves.

The bucket used to lift the alum from the storage bins is filled while standing on a flat car, which runs on a narrow-gage (24-in.) track beneath the bins. A turntable enables the car with its load to be run into the hoist shaft leading to the top floor of the chemical house. The loaded bucket is lifted by a geared hoist (capacity, 3000 lb.) mounted on a monorail in the upper story of the chemical house. The hoist is operated by a 3-hp. motor. When the bucket reaches the upper floor, it is moved by hand along the

monorail to a scale (capacity 4000 lb.), that forms a part of the monorail system. It is then transferred on the same rail system to a position directly over a circular opening in the cover of a dissolving tank. The bucket is lowered until it rests on this cover, at which time the bottom gate is opened and the alum is discharged into the dissolving tank.

An electric passenger elevator, in addition to being a convenience for the operating force, may serve as a means of carrying alum up from the bins to the dissolving tanks should the bucket hoist fail to operate. It has a lift of 56 ft., a capacity of 2500 lb. and a maximum hoist speed of 150 fpm. under full load. The shaft in which it operates is 6 ft. × 6 ft. 6 in. in plan. The elevator is driven by a 13-hp. motor operating at 900 rpm.

The dust-collecting system consists of seven hoods, one over each possible loading position of the bucket. It also includes collector piping and valves and a dust arrester with a discharge hopper and outlet equipped with a dust valve and canvas spout. The fan is driven by a 10-hp. electric motor running at 1160 rpm.

The tanks for dissolving sulfate of alumina are each 6 ft. 6 in. × 5 ft. in plan and have a depth of 6 ft. 9 in. There is a 3-in. ledge, 1 ft. above the bottom, which supports a wooden grid. This, in turn, supports a removable acid-bronze screen upon which the alum is dumped. Below the bottom of the wooden grid is a lead-pipe distribution system for furnishing the dissolving water. In a recess at the end of the dissolving tank is a wooden baffle in line with the concrete wall below. Beyond that is an acid-bronze screen designed to remove trash of all kinds from the solution before it passes into the storage tanks. The wooden grid is made in three sections and is composed of $1\frac{5}{8} \times 3\frac{5}{8}$-in. cypress joints, set on edge, with $\frac{7}{8}$-in. spaced blocks between the joists. The joists of each section are bolted together with $\frac{1}{4}$-in. bolts painted with an acid-proof paint before assembling. The bronze screens are set in cypress frames and are made of acid-proof bronze wire, 0.08 in. in diameter, 4 meshes per inch for the strainer screen and 6 meshes per inch for the screen resting on the wooden grid. The dissolving tanks were designed for a maximum charge of 4000 lb. of chemicals.

Each solution storage tank is 15 ft. $4\frac{1}{2}$ in. × 18 ft. 3 in. in plan, with an average depth of approximately 10 ft. The bottom of the tank slopes 1 ft. 6 in. in its length, with a drain at the low point. The solution outlet from the tank is 19 in. above the drain. This design was adopted to form a sump into which trash or separated aluminum hydrate might settle and not be carried into the chemicals pipelines. To effect a mixing action in the solution tanks by driving water up through a grid at the bottom and supplying make-up water for bringing the solution to a predetermined strength, four $1\frac{1}{2}$-in. lead pipes spaced equidistant across the bottom of the solution tank and tied into a 2-in. header are provided and are supplied with water through a 2-in. feed line. The four $1\frac{1}{2}$-in. laterals in the bottom of the tank are each provided with $\frac{1}{4}$-in. holes on 3-in. centers drilled in the top of the pipe.

For conveying the alum solution from the solution tanks, a pipeline leads from each set to a distributing trough over the rising well. This is a wooden trough 70 ft. long, covered with sheet

lead $\frac{3}{32}$-in. thick and hung from bolts fastened to inserts placed in the concrete floor above. The joints of the lead sheets are burned together and, on the downstream side of the trough, lead lips are spaced 2 ft. 6 in. apart. The trough is V-shaped, with a bottom angle of 90 deg. It is 18 in. wide across the top and has a depth of 7 in. above the top of the fillet. In order to obtain a uniform discharge of the solution from each lip, the level of the trough may be accurately adjusted by turnbuckles.

Administration Building

The Administration Building is a skeleton steel structure 166 × 71 ft. in plan and approximately 51 ft. high from the main floor to the underside of the roof trusses. Below the main floor are a basement and an intermediate floor. The general offices are on the main floor, with the paint shop, transformer room, pipe shop, blacksmith shop, post-ammonia room and post-chlorine room on the floor below, and the laboratories, storerooms and machine shop on the floor above. The architectural arrangement is such that an elaborate stone double-stairway leads to the main entrance to this building and advantage was taken of the space under this stairway for locating the wash-water pumproom. This room is 21 ft. 6 in. × 51 ft. 6 in. in plan, and access to it is by means of a tunnel from the basement of the Administration Building. Access is furnished to all floors by means of a freight elevator as well as by stairs. In the southeast corner of the main floor is an observation room in which is located, open to view, one of the systems of weirs which admit water to Baldwin Reservoir.

Wash-Water Pumps

There are four wash-water pumps in the wash-water pumproom for lifting water from two of the filter effluent galleries to the wash-water tanks on the top floor of the Administration Building. They are operated through electric control, actuated by means of floats in the wash-water tanks. The float contacts are arranged so that if the level of the water in the tanks continues to drop, additional pumps are thrown successively into service. Two pumps, each with a capacity of 3450 gpm., are driven by 75-hp. induction motors of the squirrel-cage type, running at 1760 rpm. and two, each with a capacity of 1850 gpm., are driven by 40-hp. motors of the same type, running at a speed of 1750 rpm. The current used for these pumps is 3-phase, 60-cycle, at a potential of 2300 volts, and is obtained from two sources —cables of the Municipal Electric Light Plant and generators at the Fairmount Water Pumping Station.

Chemical Feed Equipment

Besides the equipment necessary to apply alum solution, the Baldwin Filter Plant is equipped to treat the raw water with chlorine, ammonia and powdered activated carbon and also to add chlorine and ammonia to the water after it has passed through the filters. The pre-chlorine room contains two modern Wallace and Tiernan chlorinators, each capable of feeding 2000 lb. of chlorine per 24 hr., two chlorine flow recorders and two platform scales, capable of holding three 1-ton chlorine cylinders each. The post-chlorine room contains one of the new 2000-lb. and three of the old type 450-lb. chlorinators, one chlorine flow recorder and two platform weighing scales ca-

pable of holding one 1-ton chlorine cylinder each. Both the pre- and post-ammonia feeding equipment consist of a 300-lb. Pardee ammoniator, a home-made ammoniator having a capacity of approximately 600 lb. per day and a 5000-lb. platform scale. The machine for feeding powdered activated carbon is of the gravimetric type, furnished by the Syntron Co., and is capable of feeding 240–24,000 lb. per day.

Treatment Methods

When the Baldwin Filtration Plant was put into service, chemical treatment consisted only of the application of sulfate of alumina as the coagulant and disinfection of the filtered water with liquid chlorine, the latter consisting of relatively low dosages. Early in the year 1930, in order to combat chlorophenolic tastes and odors, treatment with ammonia in conjunction with post-chlorination was started; and in 1932, pre-ammoniation and pre-chlorination were added. In the summer of the year 1939, the method of powdered activated carbon treatment was begun, to reduce the intensity of tastes and odors caused by algae. Last year (1942) the use of ammonia was temporarily discontinued and the system of break-point chlorination was adopted for the purpose of study. Effort is being made to maintain chlorine residuals of at least 0.12 ppm. leaving the filters and 0.50 ppm. in the finished water. Results obtained so far indicate a greater efficiency in bacterial kill all the way through the filter plants, including the finished water, and apparently no deterioration in palatability, in spite of the comparatively higher chlorine residuals.

Results of tests made on the fringes of the distribution system and also at points closer to the treatment plants indicate an improvement of bacterial quality in it and show that this quality does not now become appreciably reduced. Chlorine residuals in greater or lesser amount are always found, except at the extremities of the system.

In the preparation of this portion of the presentation, the author has obtained much information and data from the paper entitled "Baldwin Filtration Plant, Cleveland, Ohio," by Messrs Ellms, Hamlin, Levy and Linders, as published in the February 1930 *Proceedings of the American Society of Civil Engineers* (Paper No. 1773).

Removable Weir Plate Assembly for Weir Installations

By D. I. Grush

PRESENTED herewith is a sketch of a weir installation with a novel removable weir plate assembly. The illustration of the removable feature is the purpose of the sketch; any structural details shown are incidental.

The idea is presented here to acquaint weir users with the usefulness and value of the assembly. No application for patent has been made or will be made, so any one may use the idea freely.

The following points regarding the usability of a removable weir plate assembly are of importance:

1. During the season when no weir readings are required the weir plate assembly is removed. This permits a straight-through flow which flushes out the forebay and also takes care of heavy flows due to runoffs, flash floods, etc. Also, with the weir removed there is less danger of washing out the structure.

2. Where weirs are in place the year round there is considerable trouble with heavy ice jamming against the weir, causing damage and washouts. With the removable weir plate assembly this damage and expense are avoided.

3. When great enough, the accumulation of sand, silt and other material in front of a weir eventually causes a higher velocity of approach than 6 ips., thus rendering the readings of little or no value. When the removable weir plate is taken out such accumulations can be readily sluiced out and the weir can be put in operation as soon as the forebay is filled.

4. Since no dimensions are shown, it should be pointed out that the sketch illustrates a smaller size weir, the removable section being small enough so that it could be removed by using bars.

5. In larger size weirs the problem of raising the removable weir assembly may be handled by erecting a head frame over the weir with provisions for using chain blocks or block and tackle. (One 16-ft. weir of this type has been in use for over a year with satisfactory results.)

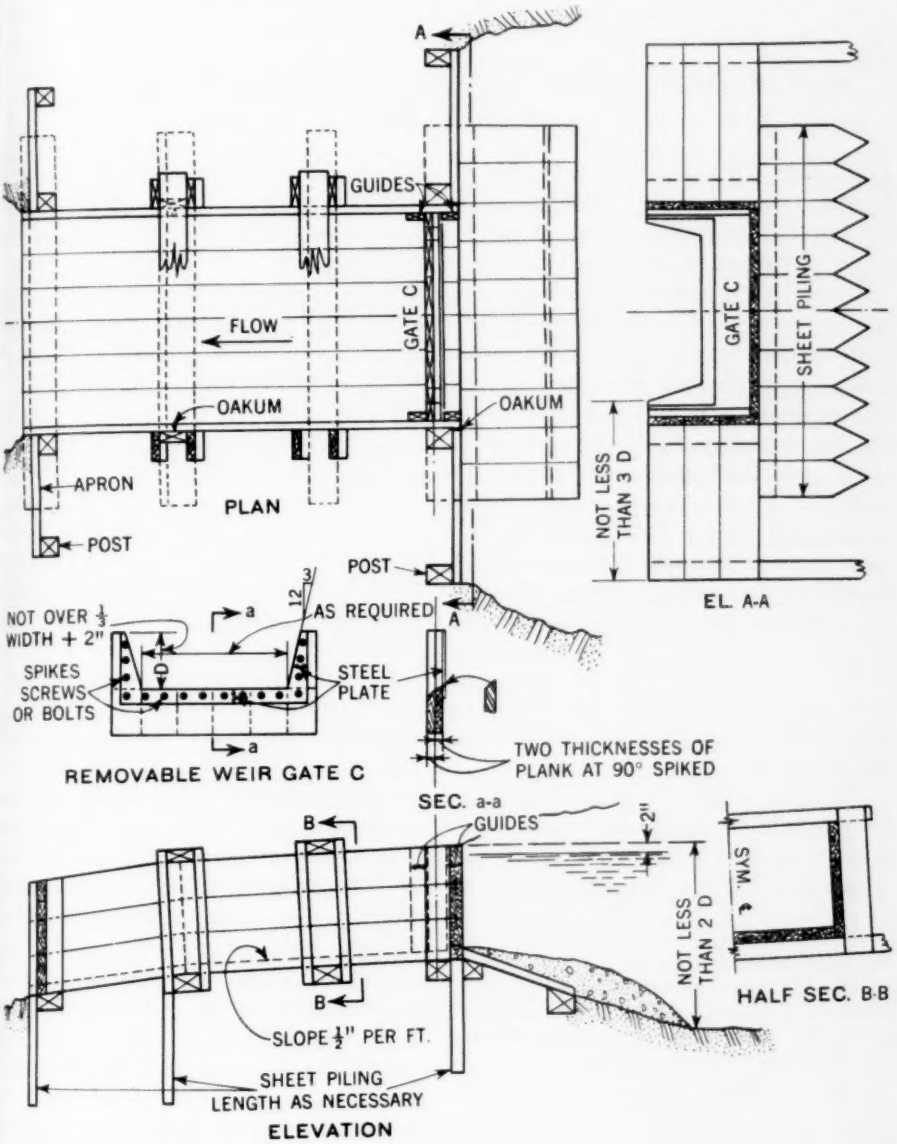
6. The suggested construction may appear more complicated and sturdy than the generally shown simple forms of weirs. Even better than the wooden construction would be a concrete structure using the removable weir plate assembly.

7. In the larger size weirs, the writer installed a 24-in. gate, wheel- and stem-operated, at the side of the weir structure. On opening this gate, the rush of water tends to sluice out

A contribution by D. I. Grush, Water Supply Supervisor, Anaconda Copper Mining Co., Anaconda, Mont.

the material in front of the weir. Then, with some hand-shovel work along the length of the weir, the power required to lift the removable section is greatly reduced. This feature is considered of value on 16-ft. and larger weirs.

8. The writer has experimented along this line for several years and feels that the information gained is sufficiently proved in practice so that it may be used with confidence as having passed the theoretical and experimental stages.



Effect of Chlorination on *Pasteurella tularensis* in Aqueous Suspension

By H. B. Foote, William L. Jellison, Edward A. Steinhaus and Glen M. Kohls

IN recent years, there have been several reports of the occurrence of *Pasteurella tularensis,* the causative agent of tularemia, in natural waters. Tularemia is a specific infectious bacterial disease of wild and domestic animals and of man caused by *Pasteurella tularensis.* Human infection is acquired most commonly by direct contact in skinning, butchering or trapping birds and mammals, especially rabbits. Many cases are contracted through the bites of deer flies and probably from many other blood-sucking insects as well as from ticks. Human infection has also been acquired from bites of wild animals and domestic pets, from removing ticks from livestock, from shearing sheep infested with ticks and from eating insufficiently cooked rabbit meat.

The first suggestion that water may be naturally contaminated came from Russia in 1934; and in 1935 an apparently water-borne epidemic of this disease occurred in that country among hayfield workers (1). Another apparently water-borne outbreak occurred in Turkey in 1936 (2). Thus far no evidence of human infection from naturally contaminated water in this country has been obtained, although many cases are on record in Montana, the sources of which have not been, or apparently cannot be, determined.

The first report of the isolation of *P. tularensis* from streams in this country was made by Parker, Jellison, Kohls and Davis (3) in 1940. A more complete report of these findings was made in 1942 by Jellison, Kohls, Butler and Weaver (4). Incident to a study of tularemia in beavers, these workers found contamination in four streams in central and western Montana, including two rivers—the Musselshell and the Beaverhead. In 1943, Parker, Steinhaus and Kohls (5) reported continuous contamination of streams by the tularemia organism for a minimum period of seven months. Their further findings, as yet unpublished, show that it may be present in mud and water at any season of the year. They have also found that streams may be contaminated in the absence of beavers and muskrats. On the other hand, the occurrence of the disease in these ani-

A paper presented on May 15, 1943, at the Montana Section Meeting, Billings, Mont., by H. B. Foote, Director of the Div. of Water and Sewage, Montana State Board of Health, and William L. Jellison, Edward A. Steinhaus and Glen M. Kohls, all of the Rocky Mountain Laboratory (Hamilton, Mont.), Div. of Infectious Diseases, National Inst. of Health.

mals is strongly indicative of contamination of the local water.

As the water supplies for many ranches, towns and even cities in Montana are taken from streams well populated with beavers and muskrats, the possibility of contamination is evident. Thirteen towns or cities in Montana now use surface water supplies which are not treated with chlorine. Surface water from private water supply sources which are not disinfected is also extensively used by individuals. Since there are no data on the effect of chlorination on *P. tularensis,* however, there has been no positive assurance that treated waters are safe for use or that chlorination should be recommended for untreated supplies as a precaution against possible water-borne tularemia infection. Therefore, at the specific request of Dr. W. F. Cogswell, Secretary of the Montana State Board of Health, the writers undertook a series of tests to obtain information on this point.

As originally conceived, these studies were to be made with two objectives in mind: first, to determine if chlorine is lethal to *P. tularensis* and, if so, in what concentrations; and second, to find, if possible, a readily usable index, such as the coliform organism test, which could be used by the water works operator and sanitary engineer to determine when proper concentrations of chlorine have been applied.

Experimental Studies

The first tests on chlorination of *P. tularensis* were made on February 1 and 2, 1940. Four cultures isolated a short time before in the study of the epizootic in beavers were used, one being taken from each of the following sources: a dead beaver, a dead fieldmouse, a water sample and a mud sample. A 24-hr. transfer on heart-cystine agar of each culture was suspended in sterile saline, filtered through gauze and centrifuged at low speed to remove particles of agar and large clumps of bacteria. Four drops of a very turbid suspension of pooled cultures were added to 400 ml. of sterile distilled water.

The coliform organisms used in the experiments were isolated from samples of water received in the water laboratory of the State Board of Health. The procedures followed in obtaining these organisms were those of *Standard Methods* (6), in which samples of the water were inoculated into nutrient lactose fermentation tubes. If gas was produced after incubation at 37°C. for the usual 24- and 48-hr. periods, transfers were made to brilliant green bile fermentation tubes. Cultures taken from the brilliant green bile tubes which showed gas production were reinoculated into nutrient lactose broth fermentation tubes.

On the eve of a series of experiments fresh transfers were made to nutrient lactose broth and, after 18 hr. of incubation, the cultures were ready for use. In each case four drops from an ordinary pipette were inoculated into the water under test. By successive dilutions it has been determined that the numbers of organisms present were probably in excess of a million per milliliter. No attempt was made to determine the exact numbers of coliform organisms used in any one series of tests for the reason that no such standardization or counting of the *P. tularensis* was easily possible.

The ortho-tolidine method of determining residual chlorine was used, taking 10 ml. of the water for each observation. Approximately 1 ml. of ortho-tolidine was added and mixed by gentle

agitation or by adding the orthotolidine to the tube and later introducing the specimen. Color comparisons were made between the unknown and standards made with potassium dichromate and copper sulfate according to standard methods. The only modification was in the size of the test tubes, which were smaller than standard, but the color standards had previously been compared with the standard tubes. No difficulty was observed in reading the residual chlorine values. All water was tested before the addition of chlorine and in no case was any color obtained upon the addition of orthotolidine.

Chlorine water was prepared by bubbling chlorine gas through water. A few drops of this chlorine water were added to the water contaminated with *P. tularensis* to effect the desired chlorine concentration. After chlorination the contaminated water was gently agitated. In Experiments 1 to 7, 1-ml. samples were removed for injection into guinea pigs to test survival of the *P. tularensis* organisms and 10-ml. samples were taken for residual chlorine determinations by the orthotolidine colorimetric test. In addition, 10-ml. samples of a suspension of coliform organisms in distilled water, similarly treated with chlorine, were placed in nutrient lactose broth in fermentation tubes for the detection of growth and formation of gas by coliform organisms.

In Experiments 1 through 9, separate suspensions were made of the coliform and tularensis organisms. These suspensions were treated with the chlorine water, an attempt being made in each series to obtain the same residual chlorine. This was not always possible, apparently because of the difference in chlorine absorption by the suspensions of the two cultures.

In Experiments 10 and 11 the cultures were mixed in the same flask and thus were given identical treatments. Since the results upon guinea pigs and in lactose broth tubes appeared to be unaffected by the mixture, this technique was followed in subsequent tests. In Experiment 17 a hypochlorite (Perchloron) was used in place of the chlorine water.

Experiments 1–5: In these experiments samples were tested at approximately 20-, 40-, 60-, 120- and 240-sec. intervals. The residual chlorine at the end of the 240-sec. (4-min.) interval was determined as a trace, 0.15, 0.15, 0.37 and 0.37 ppm., respectively. *P. tularensis* survived these chlorine concentrations up to and including the 4-min. interval as test animals died of typical tularemia.

Experiments 6–7: These experiments were conducted on the following day and were comparable to Experiments 1 to 5 except that longer intervals of time were allowed and higher concentrations of chlorine were used. Also, the aqueous suspension of *P. tularensis* used had been prepared the previous day and was possibly more sensitive to chlorination. Time intervals of 5, 15, 30, 60 and 120 min. were allowed. Test animals inoculated at the end of 5-min. chlorination, when the residual chlorine concentration was 0.4 ppm. in Experiment 6 and 0.9 ppm. in Experiment 7, however, survived, indicating that the *P. tularensis* organisms had been killed by that time. No animal infection resulted from experiments after 15-, 30-, 60- or 120-min. intervals. The coliform organisms survived for 5 min. at a 0.6-ppm. chlorine

residual and 15-min. at a 0.1-ppm. residual.

Although Experiments 1 to 7 were entirely preliminary, they indicated that *P. tularensis* in aqueous suspension would survive a residual chlorine concentration of 0.37 ppm. for 4 min. but would be killed by a concentration of 0.4 ppm. in 5 min.

Experiments 8–12: On March 5, 1940, a second series of experiments was performed, based on the experimental results previously obtained. The technique and cultures used were comparable to those outlined above for Experiments 1 to 7, except that after

TABLE 1

Results of Experiments 8–12

Chlorine Concentration	*P. tularensis:*	
	Survived	Killed in
ppm.	*min.*	*min.*
0.15	30	60
0.35	6	8
0.90	2	4

contamination with *P. tularensis* two samples (Experiments 10 and 11) were also contaminated with four drops of an 18-hr. broth culture of coliform organisms.

In Experiments 10 and 11, after chlorination, when 1- to 5-ml. samples were removed for injection into animals to test survival or death of *P. tularensis,* a 10-ml. sample was transferred to fermentation tubes to test survival of the coliform organisms. In this way the tularensis and coliform organisms were subject to identical chlorine concentrations and the resistance of the two organisms to chlorination compared.

The results of Experiments 8 to 12 ar summarized in Table 1. If Experiments 9 and 12 are omitted from consideration the survival factors for *P. tularensis,* obtained by multiplying the maximum survival period, in minutes, by the residual chlorine concentration, in parts per million, are quite comparable, i.e., 2.10, 1.80 and 2.40, respectively, for Experiments 8, 10 and 11. The lethal factor which can also be calculated is 2.80, 3.60 and 3.60, respectively, an average of 3.33. In the three tests no survival factor exceeds a lethal factor. This also holds true in Experiments 10 and 11, in which the coliform organisms were subjected to the identical chlorination treatment as the *P. tularensis,* where the survival factors are 1.8 and 2.4, respectively, and the lethal factor is 3.60 in each instance.

Experiments 13–17: To check previous results and to make a comparison between the use of distilled water and natural stream water a third series of experiments was initiated on December 19, 1940. In these experiments water from a beaver pond close to the Bitter Root River near Darby, Mont., was used. Freshly peeled twigs in the pond evidenced recent beaver activity. A good stream of water was flowing over and through the dam at the lower end of the pond so the water was not stagnant. Physical and chemical properties of the water were:

pH	7.3
Temp. (during expts.) °C.	15.5–18.5
Total minerals, *ppm.*	130.0
Iron (Fe)	trace
Chloride (Cl), *ppm.*	2.0
Calcium (Ca), *ppm.*	7.5
Magnesium (Mg), *ppm.*	0.0
Carbonate radicle (CO_3), *ppm.*	0.0
Bicarbonate radicle (HCO_3), *ppm.*	79.3
Sulfate radicle (SO_4), *ppm.*	38.9

Before contamination with the test organisms, 10 ml. of untreated water were inoculated intraperitoneally into each of four guinea pigs to determine the possible presence of any infectious agent in the water that might invalidate the experimental results. One of these control animals died on the eleventh day. The animal was severely emaciated but autopsy did not suggest tularemic infection. The other three survived and showed no sign of illness. A few deaths from unknown causes have been experienced in other test animals following inoculation of large doses of water from streams and ponds, but the infectious agent or agents or cause of death have not been determined.

The culture of *P. tularensis* used was freshly isolated by animal passage from a strain maintained in the laboratory and was of very high virulence for guinea pigs. The desired suspension was prepared by washing 24-hr. test-tube slant cultures on heart-cystine agar in sterile distilled water, filtering the suspension through gauze, centrifuging at low speed and diluting to 400 ml. This stock suspension was just

TABLE 2

Results of Experiments 13–17

Organism		Control Animal and Culture	Contact Time (*min.*) Chlorine and Culture								Expt. No.
			5	10	15	20	30	45	60	120	
P. tularensis	Residual chlorine†	+*	+	+	+	+	+	+	+	−	13
		0.0	0.20	0.18	0.15	0.15	0.15	0.15	0.15	0.12	
Coliform organisms		+‡	+	+	+	+	+	+	+	+	
P. tularensis	Residual chlorine	+	+	+	+	+	+	−	−	−	15
		0.0	0.30	0.30	0.30	0.30	0.30	0.25	0.25	0.15	
Coliform organisms		+	+	+	+	+	+	+	+	+	
P. tularensis	Residual chlorine	+	−	+	+	−	−	−	−	−	17
		0.0	0.40	0.40	0.40	0.35	0.35	0.35	0.35	0.30	
Coliform organisms		+	+	+	+	+	+	+	+	−	
P. tularensis	Residual chlorine	+	+	+	+	−	−	−	−	−	14
		0.0	0.45	0.45	0.40	0.40	0.40	0.40	0.35	0.35	
Coliform organisms		+	+	+	+	+	+	−	−	−	
P. tularensis	Residual chlorine	+	−	−	−	−	−	−	−	−	16
		0.0	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.55	
Coliform organisms		+	+	+	−	+	−	−	−	−	

* Plus in this line indicates organism infective, test animal died; minus indicates organism rendered noninfective, test animal lived.

† Residual chlorine, in ppm., determined by ortho-tolidine; the reduction in residual between the 5-min. and longer contact periods represents the loss of chlorine due to its chemical combination with constituents of the water.

‡ Plus in this line indicates organism unaffected; minus indicates organism rendered inactive.

perceptibly turbid in strong sunlight. Four drops of suspension were added to 400 ml. of pond water in a liter bottle for chlorination treatment. The same 400-ml. portion was also contaminated with four drops of an 18-hr. broth culture of coliform organisms obtained as described in the earlier experiments. Before chlorination and at regular intervals thereafter, chlorinated samples were removed for animal inoculation, for transfer to nutrient lactose broth fermentation tubes and for residual chlorine determination by ortho-tolidine tests. The results of this series of experiments are summarized in Table 2.

On the basis of previous experiments it was possible to adjust the chlorine concentration so that part of each series of experimental animals, except those in Experiment 16, survived and part died of tularemia. Experiments 16 and 17 were made in the afternoon after the *P. tularensis* had been in aqueous suspension for four hours or longer, which possibly affected the results of the experiment.

Experiment 17 was made using sodium hypochlorite as a source of chlorine. Based on the results of the single test, however, it is felt that this should in no way invalidate the results nor justify a statement that the hypochlorite was even more effective than liquid chlorine.

In Experiments 13 to 16, *P. tularensis* survived residual chlorine concentrations as follows: 0.20 ppm. for 60 min., 0.30 ppm. for 30 min., and 0.45 ppm. for 20 min., giving survival factors (time, in min., multiplied by concentration, in ppm.) of 12, 9 and 9, respectively, an average of 10. It was killed by concentrations as follows: 0.20 ppm. in 120 min., 0.30 ppm. in 45 min. and 0.45 ppm. in 30 min., the lethal factors being 24, 13.5 and 13.5, respectively, an average of 15.66+. No survival factor exceeded a lethal factor. In all tests of coliform organisms they survived longer at each residual chlorine concentration than did *P. tularensis*.

These survival factors are distinctly higher than in Experiments 10 and 11—in fact, about five times as high. Whether this is due to the use of pond water rather than distilled water as a test medium is not certain. A more virulent strain of *P. tularensis* was also used. The temperature of the water may also have been a factor, as the first tests were run with water at a temperature of about 23°C. and the last series with water brought in from outside ponds at temperatures of between 15.5° and 18.5°C. during the period of the experiments.

Experiments (18–19) Under Natural Conditions: The laboratory findings described above seemed clearly to demonstrate the efficacy of chlorination in the killing of *P. tularensis*, but to check these results further and to demonstrate the efficacy of chlorination when applied to waters naturally infected, a situation was sought in which a field test could be applied. An opportunity presented itself in the late spring of 1942 when a small tributary of Gird Creek, arising in swampy land east of Hamilton, Mont., was found to be contaminated, a test being made on May 9, 1942. It was possible in this case to divert a small amount of this water from the main stream so that it could be disinfected.

While this was considered a preliminary study, the results were definite, in that all test guinea pigs were protected from infection through the chlorination

of the water, even in low concentrations of the disinfectant. Although seven of the eight control test pigs were killed by tularemia when inoculated with unchlorinated water, the water was rendered harmless when treated to as low a dosage as to give a residual of 0.1 ppm. chlorine after 15 min. contact. Higher dosages were equally efficacious since all 36 of the test animals that were inoculated with chlorinated water survived.

To check these results and to eliminate certain uncontrolled factors in the first attempt, a second study (Experiment 19) was made on February 19, 1943. At this time there were available two wooden troughs made to definite dimensions and provided with "under" and "over" baffles to affect thorough mixing of water and disinfectant and to prevent "short-circuiting" of the water as it flowed through the troughs. Figure 1 shows how these structures were set and operated.

By controlling the volume of water flowing through the troughs, the time of contact was controlled. The dosage of chlorine was controllable; the residual chlorine tests were made at the proper intervals with a Hellige type colorimeter and sunlight was excluded. The rate of water flow was determined by measuring the volume flowing from the last trough in 1 min. These measurements were made many times during the course of the experiment. An attempt was made to keep the flow at 8 cu. ft. per hr. (1 gpm.). It was possible thus to adjust the waste or relief valve so as to maintain this flow well within the limits of practical operation of the usual gravity or pump flows in water supply plants.

Guinea pigs were inoculated in the field, the water samples being taken directly into syringes and injected into the test animals immediately. Samples for coliform and total bacterial content were collected in sterile bottles, packed in ice and taken to the laboratory where the tests were started within 24 hr. of collection.

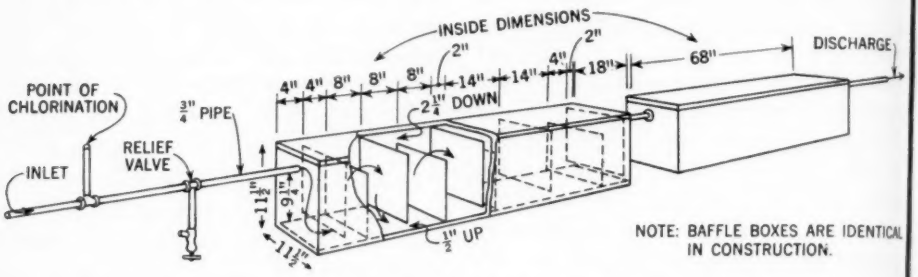


FIG. 1. Apparatus Used in Studies of Chlorination of *Pasteurella tularensis*

The results of this experiment are shown in Table 3. Unlike the results obtained from Experiment 18, in which all the guinea pigs were saved, even with the lowest dosages of chlorine, the lower dosages were insufficient to kill all of the *P. tularensis* in 15 min. It apparently required as much as 1 ppm. residual chlorine to kill the organism in 15 min.

All coliform organisms were destroyed by the chlorination, although these results might have been different if the samples of water had been dechlorinated immediately or had been

inoculated into nutrient broth at the time of collection.

Summary

Pasteurella tularensis, the specific agent of tularemia, has been recovered from natural waters in Montana. Contamination is frequent in streams in which beavers or muskrats are found.

TABLE 3

Results of Experiment 19

Time of Contact—Chlorine With Water	Residual Chlorine	Coliform Organisms Recovered		Total Bacterial Content, Agar Plates, 24 hr. at 37° C.	*P. tularensis* Rendered Harmless	
		No.	Size of Portion		Pigs Died	Pigs Saved
min.	*ppm.*		*ml.*			
0	0.0	+	1			
		+	5–10	210	4	0
15	0.2	0	1	60	2	2
		0	5–10			
30	0.1	0	1	55	0	4
		0	5–10			
60	0.08	0	1	60	0	4
		0	5–10			
15	0.5	0	1	90	1	3
		0	5–10			
30	0.3	0	1	65	0	4
		0	5–10			
60	0.1	—	—	—	0	4
15	1.0	0	1	85	0	4
		0	5–10			
30	1.0	0	1	120	0	4
		0	5–10			
60	0.6		—	—	0	4
0	—		—	—	4	0

There appears to be at least a possibility that man may contract the disease from the drinking of infected water; in fact, epidemics of tularemia in Russia and Turkey, attributed to the drinking of water, are on record. Many cases of tularemia are on record in Montana for which the source of infection has not been determined.

There is much untreated surface water used by the public, not only in Montana but in other mountainous sections of the country, in which beavers and/or muskrats are normally found.

The literature does not reveal information concerning the possible efficacy of water treatment as now practiced in the killing of *P. tularensis.*

Studies were undertaken to obtain some information concerning one phase of water treatment, i.e., chlorination. Guinea pigs were, of necessity, used in determining the presence of *P. tularensis* and nutrient lactose broth cultures for determining the presence of the coliform group of organisms. These two tests, run in parallel, afforded the basis for laboratory comparisons.

Conclusions

The results of these studies indicate that one of the objectives has been attained. Chlorination by means of a hypochlorite or with chlorine solutions in water will kill or render inactive *P. tularensis* as found in laboratory cultures and in the natural water course under study. Required concentrations of chlorine and time of contact vary as is to be expected. These evidently depended upon the variables present during the studies.

In one series of tests *P. tularensis* was rendered harmless by concentrations of chlorine acting for a period of time usually found effective for other infectious agents in water. This was true when the dosage was sufficiently low to give a residual chlorine content of 0.1 ppm. after 15 min. contact. In the second experiment all *P. tularensis*

were rendered harmless in 30 min. with a residual chlorine content of 0.2 ppm.

The second objective has not been definitely attained. There may be reasons why the coliform index cannot be applied, but further work is necessary and is planned for the future in the expectation that this phase will be clarified.

References

1. KARPOFF, S. P. & ANTONOFF, N. I. The Spread of Tularemia Through Water as a New Factor in Its Epidemiology. J. Bact., **32**: 243 (1936).
2. GOTSCHLICH, E. & BERKIN, TAHSIN. Epidemiologische und Bakteriologische Untersuchungen Über die Tularamie in Thrazien im Sommer 1936. Turkische Z. Hyg. Exptl. Biol., **1**: 124 (1938).
3. PARKER, R. R., JELLISON, WILLIAM L., KOHLS, GLEN M. & DAVIS, GORDON E. Pub. Health Rpts., **55**: *227* (1940).
4. JELLISON, WILLIAM L., KOHLS, GLEN M., BUTLER, W. J. & WEAVER, JAMES A. Epizootic Tularemia in the Beaver, *Castor canadensis*, and the Contamination of Stream Water With *Pasteurella tularensis*. Am. J. Hyg., **36**: 168 (1942).
5. PARKER, R. R., STEINHAUS, EDWARD A. & KOHLS, GLEN M. Tularemia in Beavers and Muskrats and the Contamination of Natural Waters and Mud by *Pasteurella tularensis* in the Northwestern United States. J. Bact., **45**: 56 (1943).
6. *Standard Methods for the Examination of Water and Sewage*. Am. Public Health Assn. & Am. Water Works Assn., New York (8th ed., 1936).

Erratum

Scalar Diagram for pH of Calcium Carbonate Equilibrium, by A. A. HIRSCH, in the May 1943 issue, page 595, solution to the example below the diagram: *for* = 7.66, *read* = 8.66.

New Developments in Ground-Water Exploration

By Carl A. Bays

SPECIAL investigations of the ground-water geology of northeastern Illinois have been in progress during the past year. Certain of the methods used in these studies have been somewhat novel in their application to ground water although they include methods commonly used in scientific geological research and in petroleum engineering. Attention has been given to all the phases of the geology of ground water in the area, but the present discussion is restricted primarily to the deep wells that penetrate the sandstone aquifers of the region.

Geological Methods

In the past the primary service of the geologist in ground-water studies in Illinois has been to make careful studies of the drill-cuttings from wells. The correlation of these records and the records kept by drillers has permitted the identification and tracing of subsurface units and has thereby increased the understanding of geological conditions over broad regions. The subsurface data obtained have been used in many practical ways, such as in the estimation of depths to producing zones in new areas, in the outlining of casing and liner programs for wells and in many others.

During the past year a number of methods not normally used in the study of drill-cuttings have been employed to permit a better understanding of the regional geology and of the physical characteristics of the various formations. These have augmented the usual sample-study of formations and have given much valuable geological data. These special methods of study include:

1. *Insoluble Residues:* The carbonate rocks—limestone and dolomite—comprise a large proportion of the formations penetrated in northeastern Illinois. Insoluble residues of samples of these formations are made by digesting samples in hydrochloric acid. The determination of the character and percentage of the residue gives much valuable information on the character of the carbonate rocks. This method had been commonly used on well samples in Illinois and elsewhere for some time prior to these special studies, but particular value has been obtained from the correlation of these data with the data obtained from the other methods described below.

A paper presented on April 8, 1943, at the Illinois Section Meeting, Springfield, Ill., by Carl A. Bays, Special Geologist, Ground-Water Geology, Illinois State Geological Survey, Urbana, Ill. Published by permission of the Chief, Illinois State Geological Survey.

2. *Heavy Accessory Minerals:* The sandstone formations are composed largely of quartz sand grains, more or less rounded and cemented; but in all these formations there is a small percentage of rare minerals. These rare or accessory minerals are diagnostic of many of the formations and indicate the sources of the sands. Most of the minerals are heavier than the quartz and can be readily separated from it by floating off the quartz in a high-gravity liquid, such as bromoform or tetrabromoethane. Studies of heavy accessory minerals have been widely used in many phases of geological work during the past decade, but were first extensively applied to well samples during the past year. They have proved useful in recognizing caving sands in wells and in tracing and identifying the sandstone-producing zones.

3. *Core Analysis:* In the oil industry, cores of the oil sands are usually taken and analyzed for permeability (usually measured in millidarcys) and porosity (usually reported as per cent by weight). Cores have not commonly been cut in water wells in Illinois in the past. However, cores obtained by the use of the Geological Survey's cable-tool core-barrel, as well as large caving fragments, obtained after shooting, and outcrop samples, have yielded samples large enough for core-analysis determinations of the porosity and permeability of all formations in northeastern Illinois. Thus, fundamental data on the character of the water-bearing strata have been obtained. It has been possible to indicate the physical limits of the rate of movement of ground water through the sandstones, to recognize that the carbonate rocks produce almost entirely from secondary crevice, cave or solution-cavity systems and not from the pore space in the rocks, and to establish from these and other data that the spacing between water wells is one of the most important factors controlling ground-water production.

4. *Size Analysis:* The use of mechanical or screen analyses of the size of grains in aquifers has long been a practice in water wells to determine screen sizes. Mechanical analyses also give data on the texture of sandstones. The data from size studies, from which sorting and other textural features are determined, indicate the permeability and porosity of the aquifers. The data may also be used for correlation of zones from well to well.

5. *Outcrop Studies:* The studies of the strata exposed at the surface of northeastern Illinois give much information as to the structural conditions which control the flow of water in that area. Studies of the producing strata which crop out in northcentral Illinois and southern Wisconsin give valuable information on the physical characters of the aquifers and the limits of rate of movement of water through them. Outcrop samples are carefully collected and compared with well samples. Insoluble residues, heavy mineral studies and porosity and permeability studies are made on outcrop samples.

6. *Miscellaneous Laboratory Techniques:* A number of other methods of laboratory study of well samples occasionally find important usage in ground-water geology. Shape of grains is an important factor controlling the permeability of sandstone aquifers; and studies of shape must be used properly to interpret porosity and permeability conditions. Microscopic study of well cuttings in thin-sections made by special techniques also gives valuable data on the texture of the aquifers. In

the carbonate rocks, special stains may be used to differentiate limestone from dolomite. In many well cuttings microfossils, which may be identified and used for correlation purposes, are also present.

Application of Geological Methods

All of the geological methods are employed to obtain an integrated analysis of the regional ground-water geology. The data from well sample studies, heavy minerals, size analyses of the sandstones, insoluble residues and core analyses contribute to understanding the stratigraphy of the region and the variations in rock character. From these data the general conditions of structure, the folding and faulting of the strata may be interpreted. The lateral continuity and variations in permeability of the water-producing zones can be recognized. The various natural factors that control the amount of ground water and the circulation of ground water can be evaluated. The natural factors that control water levels and the character of the water produced can be determined in some cases. Although a regional picture is thus obtained, the producing conditions in any individual well still may be uncertain, because of the many local variations in geological conditions and the many differences in engineering and production practice.

Oil Well Practices

Oil-well production engineering has gone far in the exact science of determining the factors controlling production of oil and the conditions within oil wells. In the oil fields numerous tools have been developed to obtain the precise information needed properly to understand oil reservoirs and to produce oil with the maximum efficiency at lowest cost. Water is no less a valuable natural resource, but the water-well industry has not progressed as rapidly in the development of tools and instruments to get a more complete knowledge of the water well and to develop, thereby, the means to increase the efficiency of water-well operation.

During the past year a number of the special oil-field methods of investigation have been used in water wells in northeastern Illinois by the Illinois Geological Survey. This work has been done in co-operation with the Halliburton Oil Well Cementing Co. and the Schlumberger Well Surveying Corp.; the splendid co-operation of the staffs of both companies is gratefully acknowledged.

Geophysical Surveys

The term "geophysical logging" or "geophysical surveying" of water wells is applied to the special oil-field methods or to the modifications thereof used in water wells. A geophysical survey of any well includes the use of several logging devices (standard electric logging, temperature logging, caliper logging, resistivometer logging, current meter surveys) and the integration of these data into a composite geophysical log.

The standard oil-field electric log is run on most rotary drilled wells to obtain an accurate log of the formations present, to determine the presence or absence of saturation in commercial quantities, to obtain correct measurements and for many other uses. Usually this service is run from specially designed instrument and winch trucks which carry the instruments, the recorders, the line for running the instruments in the well and which are complete even to facilities for dark-

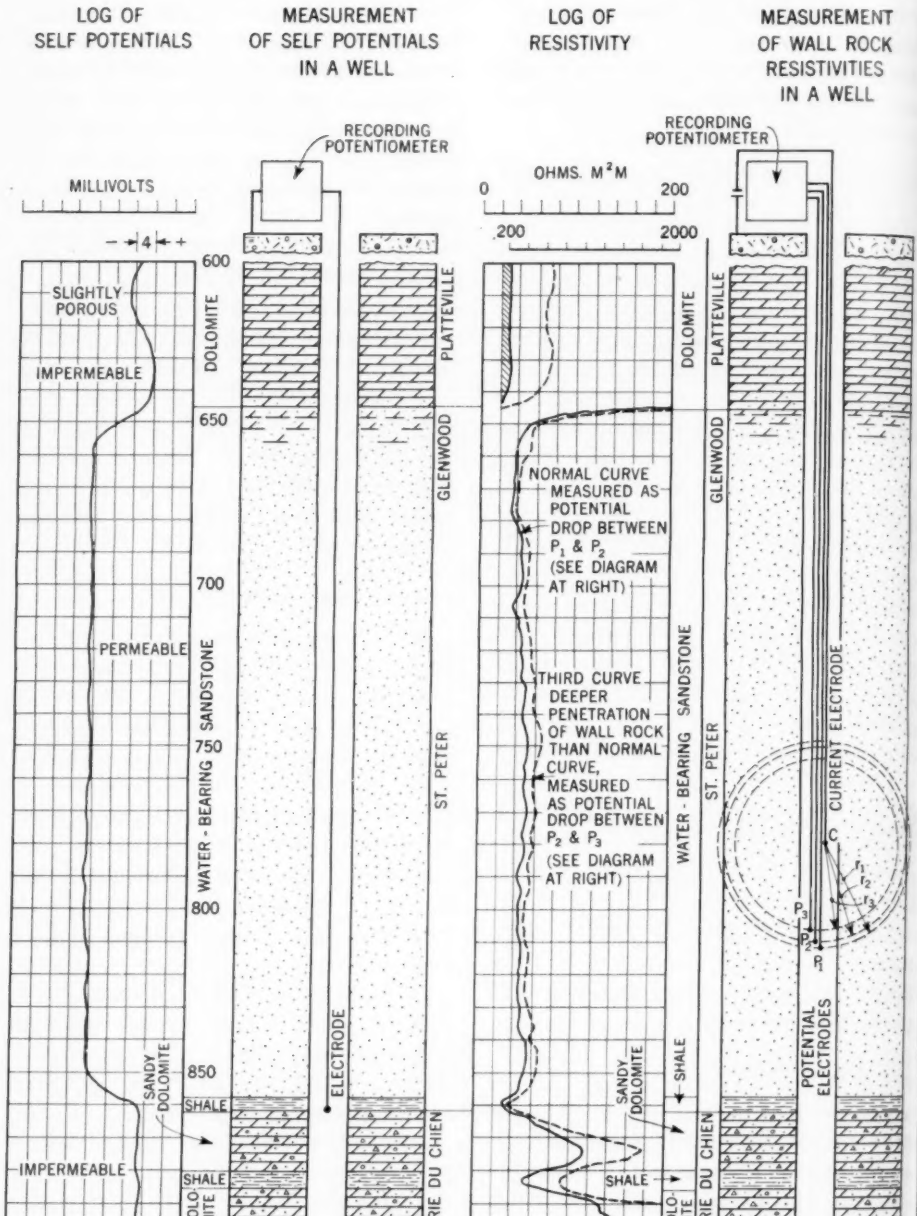


FIG. 1. Electric Logging of Water Well

room work. All observations are recorded as logs, or continuous curves, photoelectrically recorded on film or sensitized paper by very sensitive galvanometers which are motivated by the electrical circuits involved. All of the other instruments used in geophysical logging have been designed so that they may be run by the same trucks, and the data from them are recorded in the same fashion as the regular electric log.

Electric Logging: The regular electric log consists of two types of curves. Potential curves (Fig. 1) are the natural or spontaneous potential charges on the various rock formations in a well. The variations in potential curves largely reflect the porosity or permeability of the wall rock, but some other factors (such as circulation of water) which cause potential currents influence these curves. In general, high potentials (negative) indicate high porosity or effective permeability and low potentials indicate impermeable or tight zones.

The resistivity curves are made by applying current to the formations and measuring their resistivity to the applied currents. Different spacings of the electrodes which measure the resistivity are used so that different spheres of current are applied and thereby different depths of penetration are recorded. Generally, limestones and dolomites have very high resistivities, shales have low resistivities and sandstones have intermediate resistivities, dependent in part upon the character of the fluid content of the pores of the sandstone. Deep penetration curves reveal the zones of high or low salinity in sandstones, although the water in the well bore is of different composition.

Special modifications of the regular electric-log curves are made to obtain particular information on water wells. The potential curves recorded in many water wells lack relief and the sensitivity of potential measurements in some wells may be greatly increased by adding salt to the water in the well bore. Also it has been found that increasing the head of a well by keeping it filled with water during logging of the potential curve will give greatly increased values in potential in the porous zones.

Temperature Logging: A special electronic thermometer which will record temperatures of fluids as a continuous graph has been adapted for well use (Fig. 2). Temperature surveys indicate circulation conditions within water wells. Normally, anomalies are obtained in zones where water is entering the well, as from behind the casing, or where water is being lost, as in crevices of thieving zones. The temperature curves are used to locate the zones of production of water of various temperatures, and with temperature data on the production of any well, it is possible to use the temperature log to evaluate the quantities of water produced from various zones.

Caliper Surveys: The hole caliper, an instrument which is run on the standard electric logging line, consists of four movable arms which motivate a resistance so calibrated as to measure the average hole diameter. The instrument is run into the hole with the arms bound and they are released by electrical detonation of a small powder charge. The tool is then run up the hole and the log is recorded from the diameter measured by the four arms (Fig. 3).

Caliper logging has given valuable data on the effect of shooting of the sandstones, on the caving zones, on the relative hardness of various formations and on the condition of casing and liners.

Resistivometer Surveys: The resistivometer or salinity meter is used to measure the resistivity of the fluid in a well bore (Fig. 4). Measurements reflect the variations in salinity of the water. It is possible from resistivometer logs in many wells to understand the circulation conditions and to recognize the zones that produce waters of different composition.

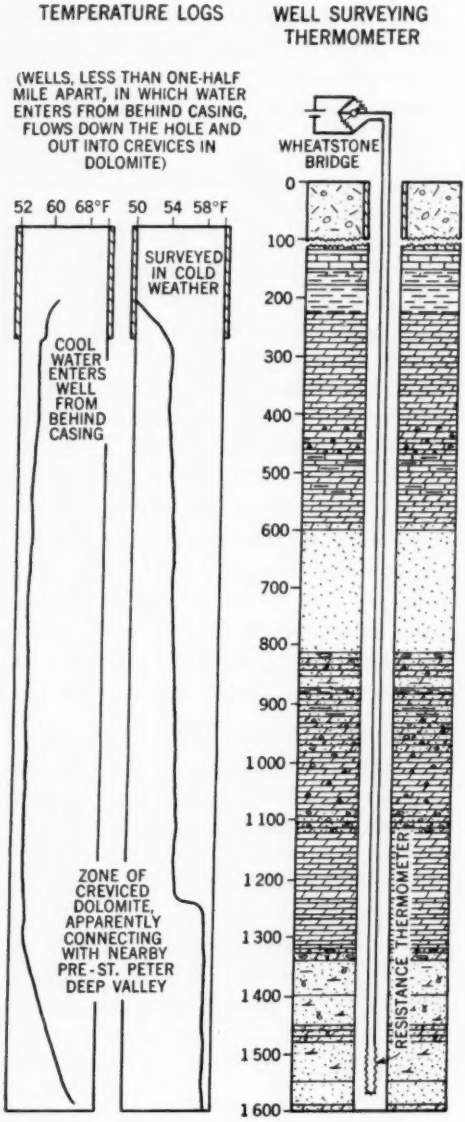


FIG. 2. Temperature Logging of Well

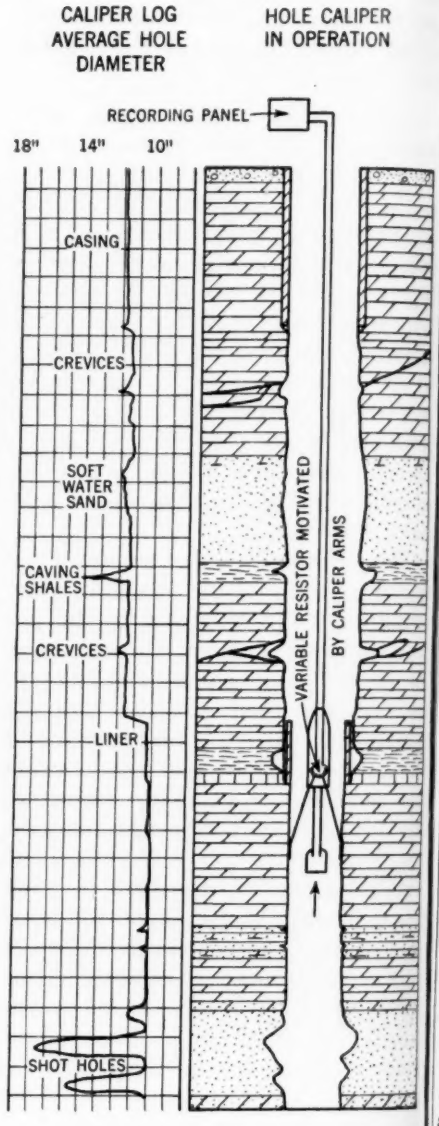


FIG. 3. Caliper Logging of Well

A technique has been developed for a fairly even distribution of salt within a well bore. After salting a well, a resistivometer survey is used to note the effect of circulation on the salt within a well. Usually the zones giving water into the well bore dilute the salt added, but in the zones where water is leaving the well bore, there is a high concentration of salt. These conditions are readily recognized.

Current Meter Surveys: The current meter is used to measure the rate and indicate the direction of move-

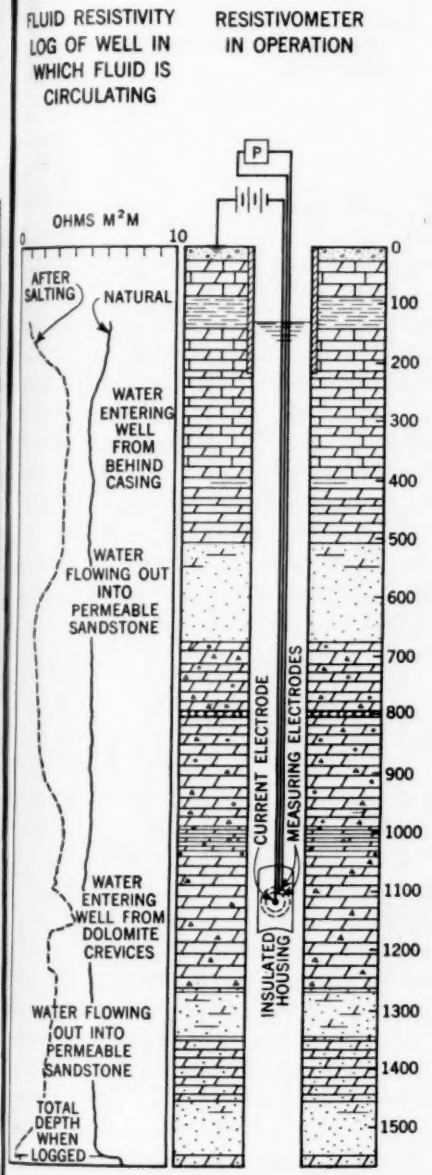


Fig. 4. Resistivometer Survey of Well

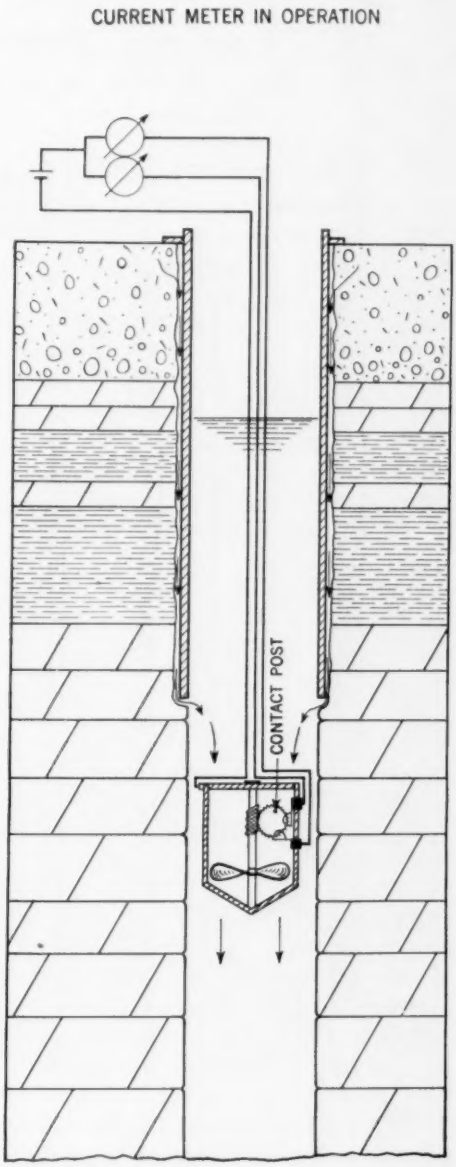


Fig. 5. Current Meter Survey of Well

ment of water within a well bore. Two types have been developed. One is a propeller meter (Fig. 5) which is so constructed as to measure rate of flow by signals received from the turning of the propeller. At each revolution of the gear, which is driven by the propeller, the contact post com-

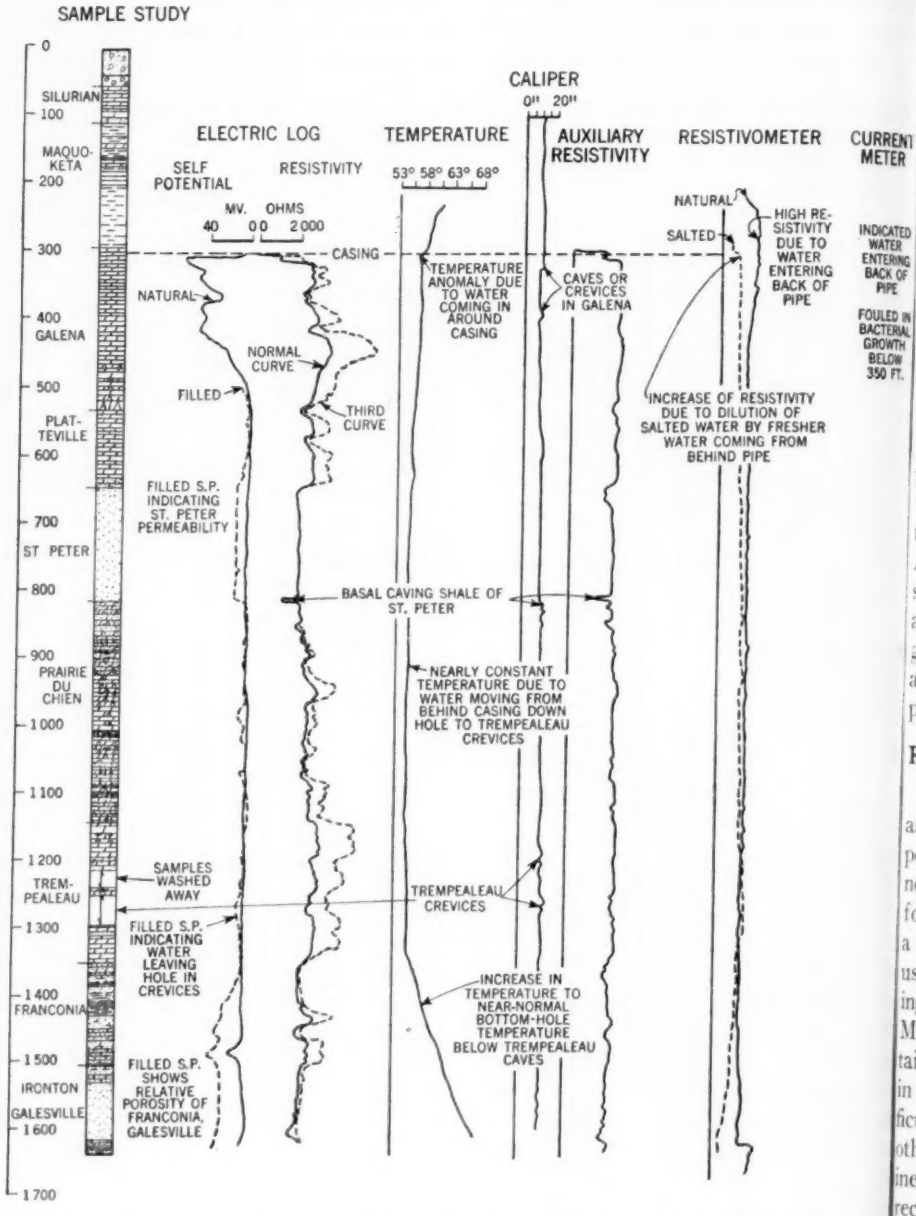


FIG. 6. Composite Geophysical Log of a Well in Will County, Ill.

ting two electrical circuits, producing different signals at the surface. The sequence of the signals indicates the direction and the frequency indicates the rate of fluid movement within the well.

The other type of meter consists of a counterweighted vane which is deflected by water movement. The vane motivates a resistance so that a continuous record of water movement in a well may be made by running the instrument at known rates of speed and deflection.

Composite Geophysical Logs: In general, the various tools used in geophysical logging give separate lines of evidence for understanding the many different problems and conditions within a water well. Together, they present a complete picture of the information that can be determined and these data should be inter-related. Also water-level data, pumpage data, sample study and other geological data are of aid in integrating the data from geophysical surveys. All of the results are grouped in a single composite geophysical log, such as is shown in Fig. 6.

Results of Geophysical Logging

Geophysical logs have permitted the assemblage of the most complete data possible on the deep water wells in northeastern Illinois. It has been found that the log of a new well forms a valuable record for the well owner's use in the operation and understanding of the production of the well. More benefit, however, has been obtained by use of geophysical surveys in older wells in which operation difficulties, pollution or contamination, or other conditions have rendered them inefficient or useless. Such wells when reconditioned by proper engineering practice usually are greatly improved.

The following specific results have been obtained in various wells surveyed:

1. A complete detailed log of all the formations not cased in the well is made.
2. The exact measurements of the position of the casing and liners are obtained and some knowledge of the condition of the pipe is usually learned in old wells.
3. The water-producing zones are located and their comparative importance within a well is evaluated. These studies have led to recognition that the producing portions of any formation are restricted in thickness and that the entire sandstone sections of the aquifers do not produce water equally.
4. A record of the salinity of the water within the well bore is obtained and the zones of production of less saline waters are usually recognized.
5. The caving zones that are not cased off within wells are readily located.
6. The thieving zones, that is, zones through which quantities of water are leaving the well bore, either under static or producing conditions, are located.
7. The circulation conditions within a well are recognized.
8. The source beds of waters of different temperature are located.
9. A number of special conditions such as water coming from behind casing, partially collapsed casing or liners, production of water from caves and crevices and similar matters may be recognized from geophysical logs.
10. The effect of shooting is evaluated by logging before and after.
11. In wells where tools have been lost or other special conditions such as parted liners, etc., occur, it is possible

to locate the iron in the hole and in some cases to give information that will permit the ready solution of such problems.

12. Exact measurements of fluid levels are made during geophysical surveys under conditions of thieving in the well and producing conditions in nearby wells, so that much valuable information on the relation between wells and causes of variation in water levels is obtained. In conjunction with geophysical logging valuable data have also been obtained by use of the echometer, an instrument for determining fluid levels by sonic reflection which can be used to measure fluid levels in pumping and non-pumping wells in which no air lines or other measuring devices are available.

13. From geophysical studies and observation of nearby wells during surveying, the relations between wells as to interference and zones of connection can be recognized. From these data conclusions as to well spacing can be reached.

Thus it is recommended that in northeastern Illinois spacing of wells to the Galesville formation should exceed 6800 ft. for optimum water level and production conditions with normal high summer pumpage and low winter pumpage. It is recommended, too, that wells to the St. Peter sandstone should be at least 4800 ft. apart under the same conditions. Where there are special pumpage conditions, variations in optimum spacing may be calculated from the geophysical survey and other data by use of formulas derived from basic laws of transmission of fluids through permeable media.

Benefits of Studies

During the period of the special studies of ground-water geology of northeastern Illinois, the geological and geophysical techniques here described have brought new understanding of the problems of ground-water production and control. Economies have been effected in water works operation by war industries and by municipalities in reconditioning or completing wells after the information was available from geophysical surveys. The results of the investigation suggest that a number of new practices may be formulated to improve the quality of water and promote more efficient use of ground-water supplies.

Purposes and Procedures of Ground-Water Surveys in Illinois

By A. M. Buswell and Max Suter

GROUND water is the principal source of water over large areas of the State of Illinois and, therefore, is a constant problem of its water utilities. For the majority of water works men, the ground-water problem involves chiefly the maintenance of wells, pumps and distribution systems in such condition that water of satisfactory quality will be available in sufficient quantities and at reasonable cost. For the state as a whole, however, the problem has much greater scope. Not only must local activities be checked and approved (a function exercised principally by the State Department of Public Health), but, over a broader field, natural resources must be studied for the purpose of locating all suitable sources of water and of determining their capacities for continued usefulness. This latter task is chiefly the function of the Illinois State Water Survey, a description of the work of which will be outlined in this paper together with some study of the results obtained.

Types of Ground-Water Use

From a geological, chemical and even technical aspect, it is possible to classify wells into two types—drift and rock. Drift wells are frequently called "shallow" wells and rock wells, "deep" wells, but these terms are misleading, since a rock well may start in rock a few feet below the ground surface and drift wells may be more than 200 ft. deep.

Drift wells and rock wells differ not only geologically, as their names indicate, but chemically as well. Drift wells show great variations in water composition because of seasonal and other influences, whereas rock wells in special cases tend to show a steady change in mineral content over an extended period. Technically, drift wells require well screens, while these can generally be omitted in rock wells.

From the hydrologic standpoint, both types of wells may be gravity wells, i.e., those in which the ground-water surface is exposed to air under atmospheric pressure. In the deeper strata of rock wells, however, artesian conditions (rare in drift wells) are also encountered. In such cases the water is enclosed between impervious rocks and under higher pressure than that exerted by the atmosphere at the depth of the bottom of the upper confining layer. As far as the source of water is concerned, gravity wells furnish relatively freshly fallen rain water, i.e., almost always water that has fallen within the

A paper presented on April 8, 1943, at the Illinois Section Meeting, Springfield, Ill., by A. M. Buswell, Chief, and Max Suter, Engr., State Water Survey, Urbana, Ill.

past ten years. On the other hand, artesian water is very old rain water, generally thousands of years old, which either fell near the site of the well at the time the deposits were formed and was covered by later sediments (connate water) or which traveled long distances from the present outcrops of the water-bearing strata. Some recent studies show that probably most of the water pumped is connate water released through a decrease of head by flow from the well; as such it is taken from old storage which is irreplaceable, although the pressure head may be restored.

These conditions and possibilities must be clearly understood by those investigating ground-water resources. The planning of such studies must take into consideration all conceivable possibilities; it should also take into consideration all the sciences that are able to shed light in any way on the solution of the problem, so that comprehensive and indisputable results obtain.

It is to be realized that such complete solutions cannot be reached overnight; yet if answers of long-term value are to be secured, data and facts must be collected to serve as the basis for the conclusions drawn.

Amount of Ground-Water Pumpage

According to data published by the State Department of Public Health, 232 Illinois communities obtain their water supply from drift wells, with a total pumpage of 40 mgd., and 215 communities obtain their water from rock wells, with a total pumpage of 47 mgd. A comparison of these figures with the pumpage of 1090 mgd. from surface water sources by 195 communities, indicates that about 7.5 per cent of total municipal pumpage in Illinois is from ground-water sources. Excluding the Chicago surface water pumpage, however, it is found that 37 per cent of the remaining municipal pumpage is from ground water. To these municipal pumpage figures must be added industrial pumpage. Although there are as yet no complete statistics on this type of pumpage, it is known, from the data on the districts that have been investigated, that industrial pumpage far exceeds municipal pumpage. In Peoria, industrial requirements are about five times as great; in the East St. Louis district about three times as great; and in the area west and south of Chicago about twice as great as public requirements.

In this connection it must be considered that, in all these places, much of the public supply water is used by industries, whereas very little industrially pumped water is used for sanitary purposes. Thus, it may be estimated that about three times as much ground water is pumped where sanitary quality is not required as where sanitary standards must be observed, i.e., about 261 mgd. against the 87 mgd. previously mentioned, even when all water taken by industrial plants from public supplies is included, as it should be, in the latter classification.

Springs furnish a very small amount of ground water in Illinois, amounting to less than 1 mgd. A large amount of ground water is extracted on farms where, as a rule, water is obtained from dug, driven or drilled wells. Although no statistics exist on the actual pumpage on farms, estimates indicate that this pumpage amounts to about 45–6 mgd. By adding an estimated farm pumpage of 50 mgd. to the figures previously given, it is found that 27 per cent of the total pumpage in the state or 75 per cent of the pumpage exclusive of that of Chicago, is from wells

These figures are as yet only approximate, but they show the magnitude of the problem as far as water resources are concerned; they show also that the municipal pumpage of ground water is only about 20 per cent of the total ground-water extraction.

Ground-water resources begin to be a problem when the all-over pumpage reaches such proportions that the general ground-water level is lowered. That is the time to start an investigation, rather than waiting till some of the wells run dry.

From the foregoing data on the distribution of pumpage, it is clear that industrial pumpage has a greater effect on the lowering of the ground-water level than municipal pumpage; yet in any comprehensive investigation a wise balance must be attempted in formulating remedial measures. Farm pumpage, although fairly large, is nowhere concentrated and therefore does not yet present difficulties.

Ground-Water Studies

In most cases, in such a comprehensive survey of the water resources, the problem at hand will determine the approach and the final selection of the method of procedure. Many other factors are to be considered, such as the length of time available, the amount of available data, the supply of technical personnel, financial support and the willingness of local interests to co-operate. The efficiency of any investigation, however, depends largely on careful planning. The type of survey which was made can best be shown by outlining the main points of the plan of study which was evolved for one of the districts (Peoria):

1. Inventory of all wells, showing location, depth and size, casing and screen data log of well, when drilled and by whom, data on chemical composition, type and capacity of pump, water level and drawdown measurements, average and maximum pumpage (Such an inventory can be made from the great amount of data available in the office files of the State Water Survey, but it should be checked in the field.)

2. Arrangements for co-operation with all interested agencies and industries, including federal, state and local agencies, civic, commercial and professional organizations, as well as the leaders of the local industries

3. Inspection of all wells to determine:

(a) Where water levels can be obtained to be expressed in mean sea-level (This requires leveling in of the wells, because taking of the elevations from topographic maps is not sufficiently exact to determine gradients between the wells.)

(b) Pumpage and its variations as to time and season

(c) Which wells could be used for readings at regular intervals, including arrangements for the taking of such readings in selected wells of favorable geographic distribution by someone from the local industrial plant, under instruction and checkup by the staff of the State Water Survey

(d) Possible causes of present conditions from available data on previous behavior of levels and pumpage

(e) Location of abandoned wells where water level recorders can be installed

4. Making of periodic analyses of water samples from selected wells and from the river to determine:

(a) Inter-connections between the waters

(b) Long-time or periodic changes in their composition

5. Study of the sources of ground water, such as:

(a) Precipitation and infiltration, including mapping of the suspected area of inflow as to its ability to absorb water

(b) The influence of the Illinois River and side creeks, by measuring their flow and levels

6. Study of the geologic conditions, with a view to determining qualitatively the possibility of the infiltered water reaching the district in which pumping occurs, requiring:

(a) Determination of the formations composing the glacial till and drift

(b) Mapping of the topography of the bedrock surface and the rock formations composing it

7. Hydraulic studies for quantitative data on flow and storage available, such as:

(a) Permeability and porosity measurements of soil samples

(b) Measurements of ground-water velocities

(c) Determination of hydraulic gradients

(d) Periodic mapping of ground-water surfaces and calculation of changes in storage

8. Study of remedial measures, as:

(a) Artificial recharge in its various forms

(b) Quality of river water to replace ground water

(c) Efficiency of cooling towers in recirculating systems as a method for reducing the pumpage from the ground

9. Combination of all data to get information on the ground-water resources in general, i.e., their balance as to inflow, storage and safe rate of continuous extraction

10. Formulation of proper legal regulatory measures for the conservation of the ground-water resources.

Not all points in this program received the same degree of attention but none was neglected. In some districts where special ground-water studies are under way, as in East St. Louis and Champaign, not all phases of the program have as yet been put in operation.

In districts with deep artesian rock wells, as in the Joliet-Chicago area, additional studies have to be made because of the peculiarities of this type of ground water. Among such additional phases should be mentioned:

1. Studies with the purpose of allocating the water pumped to its various source strata, which investigation can be approached by:

(a) Consideration of well logs and casing records, which, however, are often very unreliable

(b) Checking of these data by electrical logging, a method which can be used also to learn certain physical properties of the rocks, temperature data and changes in chemical composition with depth

(c) Periodic physical and chemical analyses, especially at various pumping rates and corresponding changes in drawdown

(d) Flow measurements in wells between the different water-bearing strata

2. Geological studies, including determination of depth, slope, thickness, faults and foldings and outcrops of the different strata

3. Chemical studies on geographical changes in the water composition within each stratum

4. Hydrologic studies, including:

(a) Permeabilities of water-bearing and water-separating strata

(b) Determination of piezometric pressures in the different water-bearing strata

(c) Storage capacities and elastic properties of the different strata

(d) Determination of lateral extent of the influence of pumpage on piezometric pressures.

Requirements of Wells

Certain of these studies present great difficulties, and methods and apparatus must still be developed to increase the reliability of the results obtained. In addition, very few wells are equipped to make even the elementary measurements needed to get fundamental data. Each well should have: (1) an air-line, long enough to get dynamic water levels; (2) a tap for sampling the water on the discharge line; and (3) a meter to measure the pumpage or the time the pump operates, or both. These three measuring devices are, in fact, necessary not only for scientific studies, but are very useful in the daily operation of the wells. Air-lines permit the determination of water levels and prevent "surprise" losses of the necessary water depth for pumpage. Taps permit sampling and the exact determination of water temperatures of the well water as drawn. Without meters it is impossible to determine exact costs, so that economical production of the water is left to chance.

It goes without saying that wells in the drift should be drilled to bedrock to get the most benefit from the available water. Similarly, rock wells should be drilled to the bottom of the water-bearing stratum which is to be utilized.

From the scientific viewpoint, such wells give valuable geologic data which can be greatly increased by careful sampling of the rock formations. Observation wells near operating wells are frequently necessary to the successful completion of a scientific study, but it is a mistake to believe that such wells have only academic value. Their purpose is scientific insofar as the data they yield are used as a basis for theoretical calculations, but the results are of great practical importance in that they give information on the permeability and elasticity of the rocks and thereby help to determine available storage and interference. This information in turn gives a basis for the economic spacing of wells from the standpoint of water resources.

Results of Ground-Water Studies

A comprehensive study following such a plan should eventually lead to complete and reliable results. For the time being, it has revealed many defects in generally accepted theories. Many data have been collected and their relationships have been exactly established, but many of these relationships cannot be explained by conventional conceptions of ground-water flow.

The progress of the recession of the ground-water level has been clearly established. This recession is not continuous, as recovery occurs from time to time, but nearly every peak is lower than the preceding one.

Drift wells recover at periods of high water, but lose this recovery with a fall in the river, even if the water level in the wells is below river stage. The cause of this phenomenon cannot as yet be satisfactorily explained.

It has been found that the chemical composition of water in drift wells changes greatly, some constituents being at one period two to three times higher than at another. No unvarying explanation for these changes has been found so far, nor have the slight changes in the temperature of the water been explained, although the

first indications were that seasonal changes were responsible. Such findings indicate that it is hazardous to draw conclusions from only a few observations and emphasize the need for continuing the collection of data and the formulation of explanatory hypotheses, which, however, should be carefully tested before being accepted.

Extensive measurements of infiltration in the area believed to furnish ground water to Peoria permitted the construction of a map showing the infiltration capacities of the soils northwest of Peoria. Geologic studies have revealed a buried rock hill under Peoria and an old abandoned filled-in valley west of Peoria. Both of these geological findings had been suspected previously from hydraulic evidence.

Hydraulic measurements in the drift indicated ground-water velocities of from 50 to 100 ft. per day in the approaches to the main pumping field.

A test on a certain method of artificial recharge indicated its possibilities for reinforcing the ground-water storage, but the fact that it introduced some pollution has prevented it from being put into actual practice, chiefly because of the responsbility for such pollution which would be incurred under Illinois law.

Conclusions

Although many important data on ground-water resources in Illinois have been collected by the State Water Survey, an explanation has not been found for all phenomena. However, the fact of steady recession in the ground-water levels due to extensive pumpage from wells has been established. In some cases this recession has reached a point where it threatens the continued usefulness of the ground-water supply. Means of remedying this situation depend, at present, upon voluntary action, which often is not obtainable. Legal regulatory measures must be developed for the conservation of ground-water resources before some industrial plants are damaged through failing water supplies.

Control of Water Well Drilling

Illinois Section Committee Report

THE Illinois Section has for several years had a committee studying the possibilities of controlling water well drilling, primarily in the interest of conservation. In June 1942, this committee reported to the section that, in its opinion, legislation should be introduced to provide for an orderly collection of all pertinent data concerning ground-water resources as the first step in establishing control of water well drilling. It was suggested that the Illinois Department of Public Health be the collecting agency, because the department had engineers stationed at strategic locations all over the state. The section accepted the suggestion and asked the legislative committee to try to secure legislation as outlined. The legislative committee, however, did not wish to proceed until it was certain the entire section was solidly behind the movement. Some rather radical differences of opinions were found among the various members of the section, so that a new committee—the Committee on Control of Water Well Drilling—was appointed.

The new committee discussed the problem with various interested persons and considered numerous plans for handling the control of the ground-water resources of the state. It now wishes to suggest an entirely different method of control from that previously considered, proposing that legislation be prepared to provide for the following features:

1. A "Board of Ground-Water Control," shall be established, consisting of directors of the following departments: Public Health, Public Works, Mines and Minerals, Registration and Education and a representative of industry. A professional engineer of the Department of Registration and Education shall be appointed by this Board to serve as its technical secretary.

2. The Board shall study, investigate and determine ways and means of properly conserving and safeguarding the ground-water resources of the state.

3. A permit shall be obtained from the Board before a well is constructed, permits to be issued through the technical secretary.

4. The Board shall supply the various state departments concerned with a copy of each well permit issued.

5. Permits shall be withheld at the discretion of the Board.

6. All well drillers shall be licensed.

7. The Board shall have the author-

A committee report presented on April 8, 1943, at the Illinois Section Meeting, Springfield, Ill., by Herbert L. White, *Chairman*, San. Engr., Univ. of Illinois, Urbana, Ill. Committee personnel includes: J. J. Doland, Urbana; Guy Morrow, Peoria; H. A. Spafford, Springfield; Max Suter, Urbana; and Joseph F. Whalen, Joliet.

ity to make reasonable rules and regulations governing the following:

a. Issuance and revocation of permits granting authority to construct water or discharge wells
b. Government of the rate of extraction of ground water from various strata, and spacing of wells
c. Making well production tests and chemical analyses of well waters
d. Filing of well logs and collecting samples of well cuttings
e. Periodic reports giving the schedule of operation, the rate of discharge, water level when pumping and not pumping, the quantity pumped and notification of repairs to wells.

8. The State Department of Public Health shall have the right to make reasonable rules, regulations and orders governing the establishment of sanitary standards in well construction and governing the inspection, repair, abandonment, filling or plugging of improperly constructed, contaminated or abandoned wells.

9. The various state departments and their representatives shall have the right to inspect water and discharge wells.

10. Any persons dissatisfied with any rule or regulation shall have the right to file suit in his Circuit Court.

11. A penalty shall be made for failure to comply with the provisions of the act.

12. The Board shall prepare and print rules and regulations, prepared by the several departments, concerning the construction and operation of water and discharge wells.

Indiana Water Resources Investigations

By Charles H. Bechert

IN recognition of the vital importance of water as a natural resource, the Indiana State Legislature in 1943 voted an appropriation to provide $15,000 annually for ten years for an investigation of the state's water resources. Previous to that time, beginning in 1921, the State Conservation Department, in co-operation with the U.S. Geological Survey, had been conducting such an investigation, but had confined its study to the problem of surface waters and, because of the limited funds available, had found it necessary to undertake only a small-scale program. In addition, a ground-water survey had been under way since 1935, but this, too, was limited in scope by the small amount of money alloted. The data collected in these studies, however, had indicated that it is possible to use water at a rate in excess of natural replenishment and that, if the water resources were to be protected, it would be necessary to inventory the supply and to determine whether the water was being used wisely or wasted.

The ground-water investigations were undertaken to determine the rate of fluctuation of the ground-water table and to find out whether it was rising or falling. For this purpose there were established throughout the state a number of observation wells in which weekly measurements of the static level of the ground water were made. Abandoned wells, as well as active wells, have been used for this purpose, but where active wells are used observations are made at such times as the water level will not be directly influenced by pumping.

By 1938, approximately a hundred of these observation wells had been established, but, at the present time, because of a loss of observers to the armed forces and because of the abandonment of the Civilian Conservation Corps, which had co-operated in the program, the number being regularly read has been reduced to 66. This number is not sufficient to make conclusive predictions regarding variations in the water table throughout the state, nor have records been kept a sufficient length of time so that definite conclusions can be based on them.

Before the data obtained from these observation wells can be of material benefit in determining what is happening to the water supply, they must be correlated with rainfall and runoff statistics as well as with potential underground storage facilities and geological formations. From the data collected,

A paper presented on April 29, 1943, at the Indiana Section Meeting, Indianapolis, by Charles H. Bechert, State Engr., Div. of Eng., State Dept. of Conservation, Indianapolis.

however, it appears that the water table of the state has fallen an average of four to five feet, indicating that during the period of measurement ground water has been used at a rate greater than the normal recharge rate, thus drawing upon underground storage. With these facts at hand, the problem became one of determining whether the lowering of the water table and the draft upon the reserve water in storage constituted a temporary condition caused by a deficiency of rainfall or one based on an excessive use of water due to the large demand of war industries.

Exhaustion of Local Supply

Despite the fact that water cannot actually be *destroyed,* it must be remembered that it can be rendered unfit for human consumption and that it can be moved from one area to another by evaporation and precipitation. Thus, it is entirely possible to exhaust the useful supply where it is most needed. An example of this situation exists at the present time in the Indianapolis area. Since 1935, and more actively from 1938 to the present, the State Geology Division, in co-operation with the U.S. Geological Survey, has made a comprehensive study of the Indianapolis area water table, based on continuous data from more than fifteen wells. It will be well, here, to quote a few sections of a report on this phase of the state program published this year, to give a better understanding of the problem and the seriousness of the situation involved:

"The investigation has shown that an average of nearly 46 mgd. has been pumped from wells in the Indianapolis area, Marion County, Ind., during the period 1938–42. The pumpage increased from about 40 mgd. in 1938 to nearly 52 mgd. in 1941, and decreased to about 47 mgd. in 1942. The pumpage will probably again increase in 1943, as the result of completion of war plants now under construction.

"The ground water is pumped from sands and gravels of glacial origin and from limestones of Silurian and Devonian age that underlie the glacial drift. During the period 1938–42 an average of 60 per cent of the water pumped from wells in the area was derived from sand and gravel and 40 per cent from limestone.

"It is estimated that since the beginning of pumping in the Indianapolis area a total of 400,000,000,000 to 500,000,000,000 gal. of ground water has been pumped, of which probably about 97 per cent has been derived from recharge and about 3 per cent from storage in the water-bearing formations in the area, accompanied by declines in the ground-water levels.

"The declines in ground-water levels, that have resulted from pumping, range in different parts of the area from a few feet to more than fifty feet. The declines have been most pronounced in the downtown district of Indianapolis and in the surrounding industrial district. Overdevelopment of the ground-water supplies in these parts of the area has progressed so far that the yields of most wells in them have declined greatly, and in 1941 the total yield of the wells in the overdeveloped areas was probably less than at any time during the period 1935–41.

"The declines in ground-water levels are due not only to the pumping of ground water, but also to the general deficiency in precipitation since 1929. The accumulated deficiency in precipitation at Indianapolis during the thirteen-year period 1930–42, inclusive, was about 45 in. The two years, 1940

and 1941, had larger deficiencies in precipitation than any other two successive years on record.

"In 1942 the precipitation was slightly above normal and there was considerable improvement of the ground-water conditions, owing both to increased recharge and to the reduced quantities of water pumped from wells for public supply, power production and for sprinkling truck gardens. Conditions in the overdeveloped areas, however, are still critical."

From the above report, the importance of the problem and the need of obtaining much more factual data concerning it are evident. Until the hydrologic facts are known and until there is available an accurate bookkeeping account of the quantity of surface water, the amount of water in storage beneath the earth's surface, the amount of natural recharge and the quantity of water used in everyday life, no judicious regulation can be undertaken.

Financing of Investigations

As previously noted, the State Legislature appropriated $15,000 per year for ten years to conduct a survey of water resources. This legislation, however, authorizes only the collection of information and in no way proposes any regulatory measures regarding the use of water supplies.

In addition to this $15,000 appropriation for next year, the Ground Water Section of the State Department of Conservation has either received or been promised contributions by the State Board of Health, the State Highway Department, the State Department of Conservation itself and by other governmental agencies and interested parties. These contributions amount to slightly more than $10,000, making a total of more than $25,000 available to carry on the work. Since the survey is to be undertaken in cooperation with the U.S. Geological Survey, the federal government will match these funds, thus financing the investigations for the next year with about $50,000. It is felt that it will be possible, with this money, to make considerable progress toward obtaining the vital information necessary to determine what future course must be followed in the use and protection of the state's water supplies.

Tentative Program of Investigations

A tentative program for future study has been agreed upon. It involves spending approximately $30,000 of the total for stream-flow investigations, $15,000 for ground-water investigations and $5000 for investigations of the flow and levels of natural lakes.

In investigating surface waters, it is planned to establish additional stream-gaging stations on the more important and critical rivers and streams. With the funds available, it should be possible to operate and maintain approximately seventy such stations. About half of these will be equipped with recording instruments, while the other half will be non-recording stations, where gage-height measurements will have to be made by observers. Discharge measurements will be made on all streams at regular intervals and miscellaneous discharge measurements will be made on various other streams where some specific problem may exist.

For studying the natural lakes, it is planned to establish additional lake gages which will give a continuous record of the level of the lakes. It is also planned to determine the inflow or outflow of some of the lakes as well as

their relationship to the ground-water levels in surrounding areas. The information obtained from these investigations will also assist in the design of control works where it is desired to establish a permanent level in a lake. The funds alloted for this part of the program will permit increasing the number of lake gage stations to approximately thirty.

The ground-water investigations are to include the establishment of many more observation wells. It is hoped to establish representative wells in every section of the state, especially in the glaciated areas. In addition to obtaining information regarding the water table through measurements in these wells, it is also planned to collect as much information as possible on the total volume of water pumped from the ground. This will require a complete survey of the state and the co-operation of all water works men and private industry. Regional studies and more detailed studies of some of the large industrial cities and war plant areas, where critical problems already exist or may exist in the near future, are also planned. Finally, it is proposed to collect as many well logs and samples of materials and waters penetrated as possible as a basis for analyzing the various water-bearing formations and the waters obtained from them.

As data are obtained in all of these investigations, they will be correlated with the rainfall data secured by the Weather Bureau, and it is hoped that, as these data are accumulated and as facts are ascertained, it will be possible to determine what steps must be taken to protect and to prevent depletion of the state's water resources.

In conjunction with these investigations, the State Division of Geology plans to carry on its recently initiated program of assisting industries, municipalities and others in determining potential water-bearing formations in areas where such information is needed for the development of water supplies.

American Water Works Association

TENTATIVE RECOMMENDED PRACTICE

—

REPAINTING ELEVATED STEEL TANKS AND WATER STORAGE TANKS

(WITH NOTES ON REPAIRS)

Approved by the Board of Directors of the A.W.W.A., June 15, 1943

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AMERICAN WATER WORKS ASSOCIATION
500 Fifth Avenue, New York 18, N.Y.

WARNING

To A.W.W.A. Members:

We wish to warn our members against the activities of parties, who, in soliciting elevated tank cleaning and painting work, have induced many towns to expend large sums of money for entirely unnecessary "repairs" to their elevated steel water tanks. One of the commonest forms of this imposition is a provision, in the cleaning and painting contract, for replacing "defective" rivets on a time basis, or at so much per rivet, or under some other arrangement which makes it advantageous for the contractor to replace as many rivets as possible.

An elevated tank should be cleaned and painted periodically. This work can usually be handled by experienced local painting contractors, but it should be kept entirely separate from any repair work.

We strongly advise against engaging or permitting any firm to inspect or repair any tank unless such firm is known by reputation and standing to be qualified to do work of that kind and can give references as to previous work performed of a similar character. The engineering problems involved are so technical that only experienced persons should undertake the work, as serious and irreparable damage to the structure may result from tampering by those who are incompetent.

There is assembled herewith a file of information upon the subject of tank painting. It includes a special report made by a committee under the chairmanship of L. R. Howson and a suggested form of contract recommended by that committee.

This information is made available so that all members of the American Water Works Association may know just how to obtain a proper job of tank painting and how to avoid becoming the victims of so-called repair firms.

Very truly yours,

American Water Works Association
By Harry E. Jordan, Secretary

July 1, 1943

TENTATIVE RECOMMENDED PRACTICE—REPAINTING ELEVATED STEEL TANKS AND WATER STORAGE TANKS

(WITH NOTES ON REPAIRS)

THE appended material constitutes an outline for use in preparing repainting specifications. In using this outline, it will be necessary for the purchaser to insert the requirements for the number of coats to be applied and the kind and color of paint. These are variables, which depend upon the condition of the surface to be painted, the type of existing coating and the color. *Since these are "painting" specifications only, no reference is made to cathodic protection, which is, however, applicable to old as well as new tanks.*

Frequency of Painting

To assure long life and to prevent the formation of deep-seated rust or corrosion, steel tanks should be thoroughly inspected both inside and out at intervals not exceeding five or six years. Where paint is exposed to unusually severe atmospheric conditions or to corrosive water, more frequent inspection and repainting will be necessary.

Number of Coats

If the old paint is in fair condition, only one coat may be required. It will probably be found, however, that, after cleaning, certain portions of the steel will be bare; these should be painted with a spot or patch coat before the finish coat is applied. If the surface is generally in bad condition, a complete primer coat should be substituted for the patch coat, in which event a total of two coats will be required on the entire structure. The extent of the painting or number of coats should be specified by the purchaser.

Inside of Tank

Experience has shown that, in practically all cases, the inside surfaces of a water tank are in worse condition than the outside. Almost without exception, tank bottoms which have had to be replaced on account of leaks through the steel, have corroded through from the inside. It is vitally important that the inside of a tank be painted as often as the exterior; and, if the water stored is particularly corrosive, the interior may have to be painted at more frequent intervals.

Kind of Paint

Underwater exposure involves very severe service for paint. The paint which, in general, has given the best results for this service is red lead and linseed oil paint (*weighing 21 to 24 lb. per gal.*) containing small amounts of litharge, which acts as a hardener. This has not, however, been satisfactory for certain waters. Asphalt paints have been found suitable for some

waters, but quite unsuitable for others. *Coal-tar enamels have also been widely used with generally satisfactory results where ice formation is not a factor.* More recently the newly developed synthetic resin type of paint has given good results under many conditions. Where experience with red lead and linseed oil paints containing litharge has been unsatisfactory, it is recommended that consideration be given to the alternate types. Where red lead and oil paints are used, it is not necessary to apply a finished coat over the red lead and the same paint may be used if a second coat is specified. In the event that two coats are necessary, however, a small amount of lamp black should be added to the second coat in order to give a darker shade and in this way to make it easier to determine whether the first coat has been entirely covered by the second.

If the old paint on the outside of the tank is black or dark green, a graphite paint may be used for the exterior surfaces. If the old paint is aluminum or a light colored paint, unless it is in fair condition, it may be necessary to apply two coats to insure a good finished appearance. If the final color desired is dark, the two coats may be necessary to cover the old light paint. If the final desired color is light gray, cream or some similar light color, the two coats will probably be necessary, as light paints do not have as good *hiding* power as dark paints. The paint used for the patch coat should be red lead or a similar suitable primer paint. If the finish coat is dark, the red lead for the patch coat should be darkened by the addition of lampblack, so that the patch areas may be successfully covered.

It is not the intention in these suggestions to recommend any particular brand or manufacturer of paints. The purchaser should consult *the tank manufacturer from whom the tank was purchased* or a reliable paint manufacturer of his own selection and determine which kind, quality and composition of paint to use, specifying the use for which it is intended.

Repairs

If any consideration is to be given to repairs to a tank at the time that it is being painted, the representative of a firm engaged in the installation of elevated water storage tanks should be called and directed to inspect the existing structure. *No contract related to repairing water storage tanks should have made a part of it any agreement related to repair work unless a prior inspection of the tank has been made and the extent of and cost of the repairs is recorded in an aggregate figure.* Certain unscrupulous painting and repair firms have solicited painting work and, after inspection of the structure, have represented to the owner that expensive repairs were necessary. Quite frequently such firms have removed hundreds of perfectly good rivets in order to replace them at so much per rivet, or per hour.

Rivets

For a great many years, it was the custom for tank manufacturers to drive tank rivets with flat heads on the inside. After a number of years, a flat-head rivet, which may have rusted to some extent, appears to have lost the major portion of its head, when, in reality, only a small part has disappeared and the rivet has many years of life left. As rivets do their work in shear and as there is very little tension force in a rivet, the head can rust entirely away before replacement is nec-

essary. As long as a rivet stays in its hole, it fulfills its function and does not have to be replaced.

Spider Rods

In the building of an elevated tank, it is the builder's custom to place rods across the top of the tank shell, under the roof, like spokes of a wheel. These are known as spider rods. As they are located near the high-water line and are alternately wet and dry, corrosion is severe and they may rust out long before the inside surfaces of the tank have been severely attacked. These rods are used for erection purposes only and may be removed, if desired, without harm to the structure. The tank builder does not recommend their replacement if they rust out. A tank repair man may claim the tank is in need of extensive repairs, after showing the owner these rusted rods. *Beware of the repair firm using the condition of the spider rods as a basis for recommending repairs.*

Leaks

If there are leaks in a tank, they may be of three kinds:

The first type is the leak through an expansion joint of a tank having the older type of cast-iron riser and wooden frost case. The remedy consists of repacking the expansion joint.

The second type is the leak at a calked joint or rivet head. Unless corrosion at this point is severe, this leak can be stopped by the use of ordinary hand calking tools.

The third type is a leak right through the plate at a point where a pit hole has eaten its way through. Such a leak may *ordinarily* exist only in the case of a very old tank or one which has not been cleaned and painted on the inside for about twenty years, *although there are rare cases of pit penetration in a shorter time due to electrolytic action or very corrosive water. In these cases the water should be analyzed and a check made to locate stray currents.* A temporary repair may be effected by the use of a patch bolt. Such a leak indicates that the entire bottom may be thin and other leaks may soon appear. The use of welding to patch such leaks is of very doubtful economy, as the heat of welding very often is the cause of new leaks. Even if a considerable area is welded, it may be but a short time after such repairs are made before new leaks appear. The only entirely satisfactory cure is the replacement of the entire bottom. This should be done by the manufacturer or by a regular tank construction company. If it is desired to postpone such replacement, leaks may be temporarily stopped with patch bolts as they appear and such repair may suffice for a few years.

Inspections

When a large water tank reaches twenty years of age or more and the owner suspects that maintenance has not been of the best, it would be advisable to have a complete inspection made. Usually the tank manufacturer has experienced men for this service, who, for a nominal charge, will submit a report showing the condition of all parts of the structure. In case of doubt as to the need of repairs, the manufacturer should be consulted.

Precautions

In painting the interiors of closed tanks, adequate ventilation should be provided to remove fumes and prevent injury to workmen or the possibility of accumulating volatile gases.

Proposed Specifications for Repainting Elevated Steel Tanks and Water Storage Tanks

1. General

The contractor shall furnish all labor, machinery, tools, rigging, brushes and all cleaning and painting materials necessary to clean and paint the structure in strict conformity with the requirements of these specifications.

(If owner elects to furnish the paint, it shall be so stated at this point.)

2. Cleaning

All dirt, rust, loose mill scale and loose paint shall be removed by means of scrapers and wire brushes. *Special care shall be used to clean all pits and roughened areas.* If any rust forms on the cleaned surface it shall be entirely removed before any paint is applied.

All rust, scale and sediment collecting inside of the tank bottom shall be entirely removed and the inside surfaces swept clean. In the case of elevated tanks, such rust, scale, etc., shall be lowered to the ground by means of a bucket and rope.

(*If the condition of the steel surface is such that the above means are incapable of properly cleaning the steel and sandblasting must be resorted to, paragraph 3, below, shall be used in place of paragraph 2.*)

3. Cleaning by Sandblast

If cleaning, as outlined under paragraph 2 above, is not effective, sandblast shall be used. In such case, the sandblast equipment shall be in good working condition and shall have ample capacity to furnish the required volume of compressed air at sufficient pressure to operate the sandblast effectively. The sand used shall be largely composed of silica grains and shall be sharp and as coarse as it is practicable to use. Provision shall be made to prevent the spreading of sand to adjoining property. All rust, mill scale, grease or other material shall be removed from the steel so as to expose the bright metal over the entire surface to be cleaned. No more area shall be sandblasted than can be painted on the same day that the cleaning is done. If rust forms on the cleaned surface from any cause, it shall be removed before any paint is applied.

4. Quality of Paint

The paint to be used shall be ready-mixed and shall arrive at the job in the original sealed cans or drums, bearing the manufacturer's name. *Two pounds* of litharge shall be added to *each gallon* of red lead paint used on submerged surfaces. *Litharge shall be added only to such quantity of paint as will be applied within the half day following. No paint containing litharge shall be used if it has stood overnight.*

The brand or manufacturer of the paint shall be as agreed upon between the purchaser and contractor, it being understood that only the best grade of paint, from well known, reliable paint manufacturers, will be used. No paint shall be applied until approved by the authorized representative of the customer. Heavy pigment paints shall be well stirred each time before paint is

withdrawn from a large container. If the pigment shows a tendency to settle, frequent stirring is necessary during the painting operation. If the paint is too heavy for use, it shall be thinned with *such thinner as the manufacturer may specify for the particular paint used.* (*No gasoline or benzene shall be used.*)

5. Application

The number of coats, color and kind of paint shall be specified by the customer. The first coat of paint shall be applied to the cleaned and perfectly dry surface before rusting begins. Additional coats shall be applied only under favorable conditions. All paint shall be applied by skilled painters and shall be carefully brushed out to a thin uniform coating, working carefully around rivet heads, joints and other irregularities in the surface. Each coat shall be allowed to dry thoroughly before the next coat is applied. Paint shall be applied only when the air temperature is at or above 40°F. It shall not be applied during wet or foggy weather or upon damp surfaces or upon metals containing frost.

Abstracts of Water Works Literature

Key: In the reference to the publication in which the abstracted article appears, **34:** 412 (Mar. '42) indicates volume 34, page 412, issue dated March 1942. If the publication is paged by the issue, **34:** 3: 56 (Mar. '42) indicates volume 34, number 3, page 56, issue dated March 1942. Initials following an abstract indicate reproduction, by permission, from periodicals, as follows: *B.H.—Bulletin of Hygiene (British); C.A.—Chemical Abstracts; P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research (British); I.M.—Institute of Metals (British).*

WARTIME WATER WORKS PROBLEMS

The Sanitary Engineer in the Postwar World. ABEL WOLMAN. W.W. & Sew. **90:** 3: 105 (Mar. '43). If we assume prosperous period after war rather than collapse of U.S.—if not the world—immediate problems will be: shift of about ½ of present total annual expenditures to peacetime purposes; shift of 10 million military personnel to peacetime occupations; shift of addnl. 20 million persons from wartime industries to peacetime industry; conversion of all war industry to peacetime industry and reorientation for peace of those communities disturbed and upset by war. Based on what we have not done in eng. since '40, and what we customarily do during normal intervals, by '44 we will have deferred demand for housing of 3.7 billion dollars; in general pub. works 1.8 billion dollars and in water supply and sewage 750 million dollars. In Ohio R. basin alone, sewage treatment costing 200 million dollars waits to be accomplished. Isolation of U.S. from obligations as world power impossible after war. This implies opportunities where our experience and developments be made available to all countries. If it means resurrection of a country, T.V.A.'s on Danube or Jordan desirable. Technological problems will be as profound as legal and fiscal. Eng. must play a dominant part.—*F. J. Maier.*

The Institution of Water Engineers. GEO. F. ATKINSON. Wtr. & Wtr. Eng. (Br.) **46:** 65 (Feb. '43). War drawn together closer than ever water engrs. of country. One desirable work of Institution to encourage young engrs. in profession. At summer meetings, noticeable that small proportion of junior engrs. attended. Difficulties may have been expense and getting leave. Difficulties would disappear by assistance from local sections. Nationalization of fire service recently taken place and shown need for closest co-operation between water engrs. and Natl. Fire Service in providing water for extinguishing fires. With peace comes process of reconstr. First program will, no doubt, be housing. All schemes will require supply of water and its distr. altered to suit demands in forthcoming era. During last 30 yr. consumption of water steadily increased. Are we to anticipate figure as high as U.S.A.? Youths with flair for civil eng. being encouraged to attend college but only to be of assistance in present natl. interests. When engrs. in services return to civil employment, they will not have had correct training for civil eng. employment. Water engrs. will have felt great shortage in trainees for water engrs. At end of '39, Institution membership stood at 861. Now 849. Loss due to war casualties low.—*H. E. Babbitt.*

How to Hold Essential Men. FRANK C. WHITMORE. Chem. & Eng. News **21:** 751 (May 25, '43). Specific suggestions for retaining trained manpower where most serviceable in the production army include: (1) Contact and explain problem to Occupational Adviser for state headquarters of Selective Service System. (2) Explain needs for personnel to local office of U.S. Employment Service and canvass technical schools so

that evidence of attempts at replacement may be shown. (3) Check exact Selective Service status of technical employees and send affidavit of their ability to local boards. (4) Arrange set of manning tables and replacement schedules to satisfy State Director of Selective Service or Regional Office of War Manpower Com. Non-replaceability of each man should be clearly indicated. (5) One month before expiration of given deferment, request continuation by submitting up-to-date information to local board. (6) If necessary man is placed in Class I-A, ask reconsideration within 10-day legal period and for transfer of appeal to the jurisdiction of local board covering plant. (7) If classification remains unchanged, appeal forwarded to District Appeal Board. (8) Appeal case to State Director to have Appeal Board or local board reconsider. (9) Handle each case individually. Do not entrust mimeographed forms to partially informed clerk. Employer's duty to fight each legitimate case to the last; defeats then rare.—*A. A. Hirsch.*

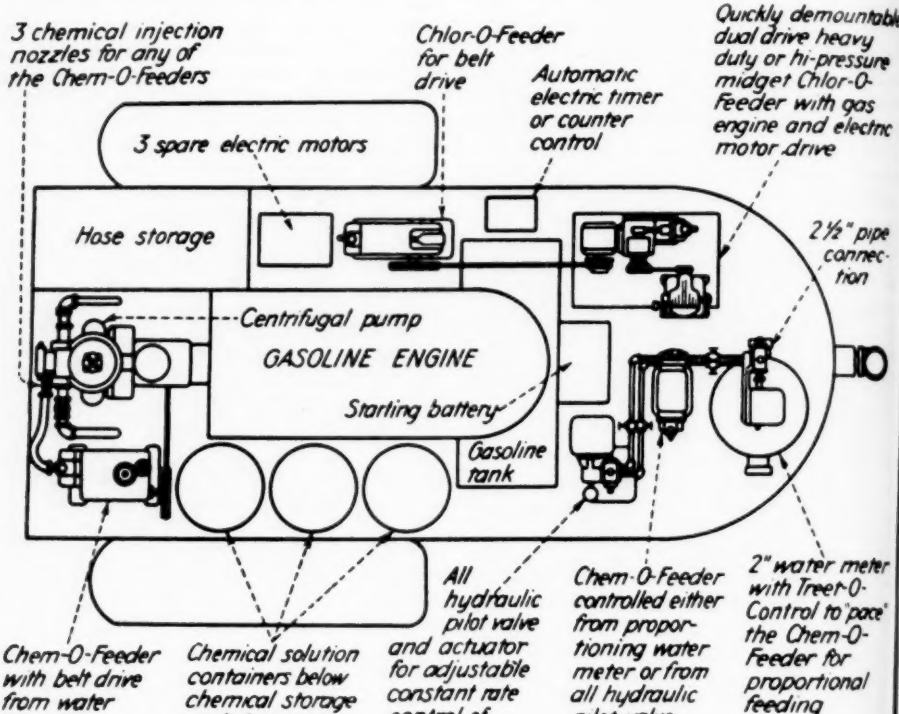
What is Camouflage? HARPER GOFF. Southwest W.W. Jour. **24:** 11: 11 (Feb. '43). Camouflage like a dike. Purpose to keep river of destruction away. As necessary to protect production capac. of plants by confusing camouflage as to protect shores against invasion. Camouflage more than science, an art with definite technique—a tailor-made job—custom-built to last detail. Mass production methods cannot be employed; each plant must be studied on the spot by "camoufleur" who must be familiar with operations of plant, traffic problems, local terrain, kinds of foliage and vegetation, weather, seasonal and atmospheric conditions and type and constr. of bldgs. surrounding plant. Perhaps most important weapons of concealment color and texture, use of infra-red, heat-deflecting camouflage paints and those compounded for low visibility; others are nets, artificial and natural foliage and earth. Camouflage is 3-dimensional problem with sunlight and shadows ever changing and temporary, cheap, fireproof, water- and wind-proof structures. Since photographic app. designed to detect ordinary paint and net camouflage, special camouflage paints which react as does natural foliage should be used. When desirable to hide or obscure adjacent reference points several miles apart, area camouflages must be used, wherein co-op. of everyone in target area required.—*Otto M. Smith.*

Suggestions for a Popular Gas Lecture. OTTO EISENSCHIML. Chem. & Eng. News **21:** 760 (May 25, '43). Chances of survival against poison gas much better than when exposed to bombs or bullets. First use of gas in warfare on Apr. 22. '15 by Germans at Ypres, Belgium. Self protection steps are: get indoors quickly, cover head and face to protect against spray; hold wet handkerchief, paper or Kleenex before mouth and nose. Few whiffs do not injure, but avoid prolonged exposure. Make one room gasproof by stuffing all cracks with wet rags, paper or twine. Have bedsheets or tablecloth handy to stretch over broken windows. Lay phosgene victims on back; do not use artificial respiration. Both mustard and Lewisite persistent and penetrate ordinary clothing or rubber gloves. Liquid mustard must be removed within 3 min., Lewisite 1 min., or poison penetrates skin. If sprayed with either, disrobe and clean off with copious water and soap before entering bldg. so material will not be carried inside. Blot off splotches without smearing. Irrigate eyes with diluted hydrogen peroxide or baking soda. Speed more important than later hospitalization.—*A. A. Hirsch.*

Mustard Gas in Air. WILLIAM RIEMAN III. Ind. Eng. Chem.—Anal. Ed. **15:** 411 (June '43). In exptl. comparison, iodoplatinate sol. found much more sensitive than Grignard reagent, alcoholic β-napthol and chlorauric acid methods. Fairly satisfactory for detecting dangerous concns. of mustard vapor, in absence of interferences, such as chlorine or reducing agents, including arsenical vesicants.—*A. A. Hirsch.*

Wells and Air Raids. ANON. The Driller **17:** 5: 8 (May '43). One way to meet emergencies from air raid damage to city water systems is to list all available good wells for use. Milwaukee, Wis., already thus prepd. Milwaukee health dept. survey shows water for drinking or other use procurable from 93 indus. and other wells in county with 36,857 gpm. capac. In addn., 9 other wells of 2040 gpm. capac. not in const. use. All 102 wells charted with detailed information. Each can be put into quick emergency use by telephone to listed key persons. Importance of good safe water supply on morale cannot be overestd. Hongkong easier to take when water supply exhausted, as Japs well knew it would be.—*Ralph E. Noble.*

Emergency Equipment for Water Works Utilities. ANON. Products Eng. **14:** 203 (Apr. '43). *Mobile Blitz Buggy* (*see* diagram) carries equip. for fire fighting, gas-infected areas and for purifying drinking water. Objective in design to provide ample capac. pump for combating incendiary attacks, war conflagrations and to provide standby auxiliary water supply service for temporary replacement of water plants, standpipes and storage tanks out of service by raid or sabotage. Other objectives to provide emergency equip. for sterilizing standpipes, storage tanks, broken water mains or cross-connections and washing bldgs. and streets with chlorinated stream to counteract residual gas effects. *Centrifugal Pump* driven by 85-hp. Ford V-8 engine largest unit mounted on blitz buggy. Pump delivers 200 gpm. at 200 psi. with 2½" discharge. Pump ball-bearings permanently grease-packed. Engine covered with sheet-metal housing, rear panel serving as instrument board for oil gage, ammeter, starting button, throttle control, choke control and ignition switch. Engine equipped with auxiliary cooler or heat exchanger so connected that circulation water returns to pump suction. Belt driven from engine drive shaft, all-purpose chem. feeder unit can be connected to discharge side of pump. Steel floor of truck welded to chassis. Storage rack for hypo cans and box for residual test kit made of sheet steel. On some models, box coated with plastic paint to protect steel from corrosion. *Compact High-Pressure Chlorine Feeder* mounted on formed steel bedplate. Unit consists of reciprocating single-acting plunger pump, gasoline engine and elec. motor. Gasoline engine ½-hp., 4-cycle, L-head, air-cooled vertical single cylinder type with high tension magneto. Also has pedal-type crank for quick starting. Pump connected to worm gear speed reduction unit driven by V-belt either by motor or engine. Elec. motor


3 chemical injection nozzles for any of the Chem-O-Feeders
Chlor-O-Feeder for belt drive
Automatic electric timer or counter control
Quickly demountable dual drive heavy duty or hi-pressure midget Chlor-O-Feeder with gas engine and electric motor drive
3 spare electric motors
Hose storage
2½" pipe connection
Centrifugal pump
GASOLINE ENGINE
Starting battery
Gasoline tank
All hydraulic pilot valve and actuator for adjustable constant rate control of Chem-O-Feeder
Chem-O-Feeder controlled either from proportioning water meter or from all hydraulic pilot valve actuator
2" water meter with Treet-O-Control to 'pace' the Chem-O-Feeder for proportional feeding
Chem-O-Feeder with belt drive from water pump
Chemical solution containers below chemical storage rack for quick action hypo can dump

mounted on c-i. plate hinged at bottom edge to crank end of pump frame casting. Top edge of plate connected to pump frame with adjustable stiff leg for regulating belt tension when motor drives pump. Pump cylinder made of transparent methyl methacrylate plastic.—*Ralph E. Noble.*

War Emergency Repairs in Great Britain. C. F. GREEVES-CARPENTER. Eng. News-Rec. **130:** 439 (Mar. 25, '43). Adequate water supply of primary importance in defense against bombings. Provision of static water for use in fighting fires given special attention, millions of gal. being stored in tanks, reservoirs, etc., at strategic points in cities. Ministry of Home Security has set emergency stds. for quant. of water to be stored in every sq.mi. of city. Some depts. maintain motorcycle dispatch riders to provide contact between various points on system in event of dislocation of other communications. Procedures for repairing broken mains include use of plastic or liquid calkings, rubber rings which may be compressed by screw threads or flanged collars to form impervious seal quickly, and sleeves held firmly by rubber rings tightly drawn in place and fastened by end-flanges connected by bolts. Plastic fillings, of which there is wide variety, require no heat nor any device to keep them in position during hardening and may be used on wet pipe. Some time required, however, for joint to become hard and impermeable. Prefabricated gasket usually calked into joint cavity before introducing plastic. Poured fillings must be melted and are not generally considered suitable. Reliance usually placed on fully mech. means of pipe jointing. Supplies of repair materials, flexible jointed pipe and steel tube for quickly spanning bomb craters maintd. at strategic depots. Customary to treat contamd. mains with as much as 50 ppm. Cl, using portable chlorinator.—*R. E. Thompson.*

The Maintenance of Water Supply Under War Conditions. ANON. Wtr. & Wtr. Eng. (Br.) **45:** 171 (Nov. '42) (*Reprinted*, Jour. A.W.W.A. **35:** 7 ('43)). *Discussion. Ibid.* **46:** 71 (Feb. '43). D. H. BALL: Has not experience shown it often preferable to have small flow of water in crater to keep escaping gas under control? Closing valves partially or wholly matter of liaison between gas and water authorities. Would it be policy to cut off and isolate streets alternately with view to reducing consumption? Would there not be greater disturbance in mains and result in more waste? Should static drinking water tanks be kept full during winter months? *Author's Reply:* Flow of water into crater must be stopped at earliest possible moment. Also opinion of gas authorities. In serious emergency, restriction of supplies would be great help. Better to have large no. of small areas without water than 1 large area. Amt. of reserve storage provided by these tanks usually small and, when prolonged, frost appears to be imminent. Simplest course would be to empty them.—*H. E. Babbitt.*

Waste-Water Survey "Saves" Plant Capacity. W. R. SCHNABEL. Eng. News-Rec. **130:** 551 (Apr. 22, '43). Prior to '37, when 10-mgd. filter plant installed to treat Little Lehigh Creek water, supply of Allentown, Pa., derived entirely from 2 large springs. Nominal capac. 22 mgd. and during period '37–'41, due to war demand, consumption increased from 13.7 to 18.93 mgd. Distr. system consists of 2 reservoirs of 10 and 30 mil.gal. capac., resp., floating on system, 169 mi. 4″–36″ c-i. pipe, some 100 yr. old, 3513 valves and 1100 fire hydrants. Services of Pb and many 75–100 yr. old. Only 320 of 24,150 services metered. As demand approaching capac. of plant, latter had to be expanded or pumpage reduced. Leakage survey therefore made and 3.17 mgd. saved by discovering and elimg. 190 underground leaks, 0.158 mgd. by curtailing plumbing fixture leakage and 0.33 mgd. by uncovering meter under-registration. House waste very low, avgg. only 6 gpd. per service. Although demand increased 2 mgd. during months just prior to survey as compared with preceding yr., on completion of survey was 1.75 mgd. less than preceding yr., indicating saving of 3.75 mgd. In addn., 200 valves found to be broken or leaking. Cost of locating and repairing leaks $21,083—equiv. to $15.80 per mil.gal. saved for period of 1 yr., but as repairs permanent, saving will extend indefinitely into future and actual cost but small fraction of that amt. Plant capac. equiv. to 3.5 mgd. obtained at cost of $6000 per mgd., i.e., ⅛ cost of filters alone. Annual under-registration of large meters discovered was 120 mil.gal., equiv. to $4800 addnl. revenue. One fire line found tapped and water used from it to extent of 0.29 mgd., equiv. to $4234 annually. Seven industrial consumers whose combined annual net bill (on flat basis) $5515 found to have

used sufficient water to raise combined annual bill to $17,429 if billed on net metered rate of 4¢ per 1000 gal. for consumers using over 0.75 mil.gal. per mo. Annual value of leakage and waste, unauthorized use under-registration and increased revenue from industrial flat rate accts. estd. to be $69,584. Public informed of results as survey progressed and thus made "leak conscious," as indicated by low house waste found.—*R. E. Thompson.*

Price Control on a Wartime Water Works Project. GLENN E. HANDS. Am. City **58:** 3: 40 (Mar. '43). War activities at Tampa, Fla., strained distr. system beyond capac. Water dept. prepd. plans for strengthening and extending system. Bids let on this plan but further study showed considerable saving could be realized by changing pipe sizes. Readvertising for bids considered too costly and time-consuming, so negotiated contract made with local contractors. These, as employees of city, would manage job; their fee based on percentage of original low bids with unit price adjustments. Contractors guaranteed that cost of work would not exceed amt. of original low bid, with adjustments, but would receive ⅓ of savings in cost below predetd. amt. These savings amtd. to 11% of total cost despite higher costs and critical shortages of material and labor. Formerly pressure of 117 psi. required to deliver 13.6 mgd.; now only 70 psi. necessary for pumping 15 mgd.—*F. J. Maier.*

Locating Farm Water Supplies for Emergency Use. WARREN R. SCHOONOVER & J. B. Brown. U.S. Dept. of Agric., Extension Service Rev. **14**: 18 (Feb. '43). By arrangement with Calif. State Council of Defense, Ext. Service assumed responsibility for insuring water supply for emergency use in rural dists. and became associated with Emergency Farm Fire Protection Project formed earlier, as it appeared essential that farm firemen know location of all emergency water supplies. Plan provided for making confidential maps showing all available emergency water sources in each county. Small area maps showing emergency sources for each small dist. would be made available for pub. use, but remain in custody of area fireman, a volunteer leader in fire protection work. Surveys and maps completed in 36 of 42 counties having county agents. More than 10,500 water points located and mapped, meet requirements of several families and accessible to those wishing to haul water, with location available through area fireman. Plans made to supply county maps to military or civilian defense authorities in charge of troop movements or civilian evacuation, thus permitting effective use of water sources throughout country in most extreme emergency. Most Calif. farm families now assured safe and dependable emergency water supply. They have been encouraged to: keep all tanks, troughs and reservoirs filled; repair and fill all unused tanks; repair or provide windmills or hand pumps; arrange auxiliary power for pump or pressure systems where practical; arrange for tank wagons or containers for hauling water; know location of nearby available supplies should hauling be necessary; est. stock and min. daily domestic requirements; store supplies of clean water for drinking and culinary purposes; and treat water for health protection if necessary to use contamd. supplies.—*Ralph E. Noble.*

Water Supplies for Relief Airfields. H. A. McINTYRE. Can. Engr.—Wtr. & Sew. **81:** 3: 18 (Mar. '43). Water supply has been one of most vital problems in construction of more than 200 airfields for Commonwealth Joint Air Training Plan. In 1 case, when ground water found to be too highly mineralized, supply developed from small river. System includes gravity intake, pumps, coagulant feeder, pressure filter, chlorinator, storage tank and distr. facilities. Vertical type filter is 54" in diam. and 76" high, has capac. of 2400 gpm. and contains 30" silica sand. Partition enables each half of filter to be washed as separate unit. Sight glass on wash-water drain enables operator to det. when filter has been sufficiently washed. Filter maintd. in service until inlet pressure rises 10 psi. above normal. Sufficient alum added to maint. pH at 7.0 or slightly higher. Sodium hypochlorite used for sterilization, 0.2 ppm. residual Cl being maintd. in distr. system. Automatically operated compressor maints. pressure between 10 and 40 psi. in 1000-gal. tank.—*R. E. Thompson.*

Fixed Dose *vs.* Horrocks Test in the Chlorination of Water Supplies in the Field. R. St. JOHN LYBURN & J. E. RIDLEY. J. Roy. Army Med. Corps. (Br.) **80:** 19 (Jan. '43). Relative merits of Horrocks test and fixed dose methods of sterilizing water supplies in field discussed. Attempt made to simplify teaching and operation by substituting fixed dose method, incorporating chloroscope with

fixed glass to match 2 ppm. Cl using orthotolidine. Experimentally tested grossly contamd. water by proposed method demonstrated importance of filtration. Concluded that fixed dose of 5 ppm. Cl extremely eff. for treating this type water. Latter effectively sterilized in 5 min. after filtration through metal filters augmented with "Kieselguhr." Light portable filter, designed for small patrol and weighing less than 20 lb. effectively fills water bottles for 50 men in 15 min. Such filter considered essential equip. for small patrols in tropical and subtropical areas for protection against tropical worm diseases and removal of bact. clumps in grossly cold waters.—*Ralph E. Noble.*

Breaking Bottlenecks in Piping Materials. D. W. HAUCK. Chem. & Eng. News, **21:** 756 (May 25, '43). Cast iron acceptable alternate for steel flanges provided operating pressures do not exceed 250 psi. satd. steam pressure or located near expansion bend. Malleable iron unions and fittings may substitute for steel. Angle valve may replace a glove valve and turn. Bypass valves may be installed separately, at later date, when available. Wedge disc or double disc valves usually interchangeable. Avoid special factory packings. Use manually operated types wherever possible. Prefabricated piping presents unlimited possibilities for welded assemblies. Beveled-end pipe bend of desired thickness and material may be made into welding elbow if latter unavailable. For a reducing screwed flange, tap a blind flange, eccentrically or concentrically. Piece of plate may be fashioned into slip on welding flange. Plugged tee may serve for elbow. Use of bushings increased by "Simplification Program."—*A. A. Hirsch.*

Small Diameter Plastic Piping Now Available in Canada. ANON. Eng. Cont. Rec. **56:** 52: 68 (Dec. 30, '42). Plastic pipe being made in Oshawa, Ont., in sizes from $\frac{1}{8}$" to $1\frac{1}{2}$" and may soon be available in diams. up to 6". Advantages are light wt. (18% of c-i. pipe of same wall thickness), freedom from corrosion, resistance to shock and high elec. resistance. Pipe not damaged by freezing of water within it and may be tapped and threaded in manner similar to that employed for metal pipe. Stoppages may be easily located in transparent types of plastic pipe. No limit to length of sections. Products are mfrd. from 3 base plastics—polyvinyl butyral, cellulose acetate butyrate and monomeric vinylidene chloride—each of which gives a different degree of hardness and flexibility.—*R. E. Thompson.*

Curtailment in the Use of Ferrous Materials in Sanitation Projects. ANON. Bol. Obras Sanit. Nacion (Arg.) **7:** 509 Jan. '43). Co-operative efforts on part of Argentinian industrialists and engrs. succeeding in solving problems created by scarcity of imported constr. material as result of war. Shortage of metallic pipe, reinforcing steel and machinery most keenly felt. Inability to continue constr. program would have resulted in serious unemployment crisis and in set-back to work being done to improve san. conditions. Saving of 4500 tons of ferrous materials already obtained by redesigning five major projects to utilize more concrete and curtail use of reinforcing steel. This policy also to be followed in designing structures such as elevated storage tanks where it is planned to use $\frac{1}{3}$ amt. of reinforcing steel required in previous designs. Further saving of critical materials accomplished by use of asbestos cement and concrete for small diam. conduits. Although in some cases, adopted policy resulted in increased constr. costs, nevertheless offered effective solution for pressing problem, making possible continuation of sanitation program, utilization of natural resources and promotion of work opportunities in all parts of the republic.—*J. M. Sanchis.*

STERILIZATION

Self-Sterilizing Surfaces. A. GOETZ, R. TRACY & S. GOETZ. Science **95:** 537 (May 22, '42). Extremely small quants. ionized Ag can have remarkable germicidal effect. Distinction between *volume* effect by small Ag concn. in water and *surface* effect when microorganisms contact surfaces of absorbed Ag. In former case, bact. effect accomplished in hours and with little change in rate up to 2 ppm. Bact. yeast and mold spores unattacked. In latter, cell destruction rapid when contact close with extreme Ag concns. in Ag-absorbed surfaces. Self-sterilization permanency dependent upon: (1) exposing only small quant. of total Ag content; (2) holding this quant. in form almost insoluble in water,

but available to proteins; (3) protecting unexposed supply from chem. attack; and (4) replacement by diffusion. Compounded substance represents varnish-like viscous fluid applied by brush, spray or impregnation to various bases like plastics, glass, wood, paper, cloth, etc. Hardened *in situ* by polymerization or evapn. of solvents. Surfaces tasteless, odorless, resistant to mech. wear and chem. attack by weak acids, alk. solns. and boiling water. Sensitive to certain org. solvents. For heavy duty, about 1 g. Ag per 1000 sq.cm. exposed surface. Almost continuously wet surfaces require high replacement rate but low water permeability to prevent premature Ag exhaustion. Test methods described. Organisms tested: *Esch. coli*, *Staph. aureus*, *B. proteus*, *B. subtilis*, *Cl. pasteurianum*, *Penicillium*, *Rhizopus* and *Sacch. cerevisiae*. Media used: dist. tap and peptone water, nutrient broth, 5% sucrose and dextrose; cider and milk. Sterilization rate varies with surface compn. Highest rate, *Esch. coli* at 10^8 cells per ml. in < 1 min. Materials requiring rates > 5 min. for *Esch. coli* at 10^6 cells per ml. discarded. Usually rate not influenced by bact. concn., but depends upon concn. of protein-like matter in suspending medium. Surface destroying *Esch. coli* in water in 2 min. requires 15 to 30 min. for sterilizing non-spore-formers in milk.—*Ralph E. Noble.*

Modern Methods of Disinfecting Public Water Supplies. NORMAN J. HOWARD. Eng. Cont. Rec. **56:** 14: 41 (Apr. 7, '43). General discussion of chlorination, Cl_2-NH_3 treatment, ozonation, ultraviolet ray treatment, excess-lime treatment and sterilization by contact with metallic Ag (Katadyn). Seems to be little likelihood of lesser used disinfection processes supplanting employment of Cl and its compds., which are used in treatment of vast majority of water supplies on this continent.—*R. E. Thompson.*

Bactericidal Effect of Ultraviolet Radiation. H. C. RENTSCHLER, R. NAGY & G. MOUROMSEFF. J. Bact. **41:** 745 (June '41). Simple method of uniformly seeding Petri dishes and prepn. of device for measuring bactericidal wave band described. Authors conclude, in part, that variation in resistivity of individual bacteria in a culture to ultraviolet radiation shown to be considerably greater than heretofore suspected. This explains many discrepancies generally attributed to other causes. Same individual organism shown to have widely different resistance to ultraviolet radiation at different stages of life cycle. In normal culture of bacteria of species such as *Esch. coli*, resistance of different bacteria at same stage of life cycle to ultraviolet may be different. Temp. of organism at time of irradiation has negligible influence upon lethal action of ultraviolet radiation provided temp. such that no injury due to heat or cold. Sublethal dose of ultraviolet radiation retards rate at which colonies develop after irradiation. Relation between amt. of ultraviolet radiation and percentage of bacteria killed in given culture detd. by distr. of bacteria of different resistivity to radiation, and not due to probability of hitting vital spot in given organism by a photon.—*P.H.E.A.*

Researches on Ultraviolet Light and Ozone and Their Relations as Germicidal Agents. ARTHUR W. EWELL. Refrig. Eng. **41:** 331 ('41). Killing of micro-organisms increases with both ozone concn. and time concn. applied. Given ozone concn. produces about same killing at 4° as at 20°. Because of much more rapid spontaneous de-ozonification at higher temp., however, more ozone required to give specified concn. Bunsen-Roscoe reciprocity law holds approx., since, for given percentage killing, product of ozone concn. multiplied by duration of application quite const. for range of ozone concns. employed in food preservation (3 ppm.), duration being less than generation time. With limited no. of expts. as criterion, increase of resistivity from one organism to another, such as from *Esch. coli* to *Aspergillus glaucus*, appears to be same for 2537 radiation as for ozone. Diffusely scattered ultraviolet light applied over several generation times may give appreciable and important germicidal effects outside of direct illumination. Ozone only germicidal form of oxygen produced by ultraviolet irradiation.—*C.A.*

Influence of Nitrogen Oxides on the Toxicity of Ozone. C. E. THORP. Ind. Eng. Chem.—News Ed. **19:** 686 ('41). Literature on prepn. and toxicity of ozone reviewed. Lab. tests with 2 types of ozonizer showed that impure ozone contg. 47% oxides of nitrogen produced by usual metal-glass-metal generator which forms ozone by spark discharge, and pure ozone by OR generator which forms ozone by action of ultraviolet rays using

generating elements of a phenol-formaldehyde plastic material. Since oxides of nitrogen known to be toxic, comparative expts. on human beings, mice, *Esch. coli*, weevils, and algae made to det. effect of impurity on toxicity of ozone. Tests made on *Esch. coli* and green algae carried out by bubbling impure or pure ozone through samples in water. Found that ozone contg. 47% oxides of nitrogen has bactericidal properties in concns. above 3 ppm. but pure ozone not bactericidal in concns. below 50 ppm. Copper sulfate, oxides of nitrogen alone, and ozone contg. 47% oxides of nitrogen, lethal to green algae, but pure ozone not. Samples of water contg. algae set aside for 6 days after aeration with test gases; samples aerated with pure ozone showed considerable increase in growth but no new growth occurred in rest of samples. Tests on human beings showed that toxic limit for ozone contg. 47% oxides of nitrogen 1 ppm., but exposure for 4 hr. to air contg. 20 ppm. pure ozone had no ill effects. Concluded that presence of ozone increases toxicity of oxides of nitrogen to considerable degree. —*W.P.R.*

Mobile Ozone Unit for Water Purification. ANON. Eng. News-Rec. **127:** 807 (Dec. 4, '41). Mobile, fully automatic unit developed by Technicraft Eng. Co., Los Angeles, described briefly. Water pumped from source through filter to remove suspended matter and then through absorber chamber where sterilization effected. Power supplied by gasoline-engine driven unit. Ozone generated from filtered dried air by high-frequency silent blue elec. discharge between aluminum plates maintd. at 13,000 v. by 2-kva. transformer. Ozonized air flows through absorber countercurrent to water in 4 separate stages, providing diffusion, injection, turbulation and scrubbing action. When requirements greater than 9,000 gph., units operate in parallel.—*R. E. Thompson.*

A Portable Emergency Chlorinator. ALBION A. BAILEY. W.W. & Sew. **89:** 347 (Aug. '42). Device designed primarily for emergency chlorination of broken water mains consists of machined hard rubber ejector, 2 lengths of 1″ rubber hose, 6′ of ¼″ copper tubing for chlorine supply and soln. tube. Chlorine supplied directly from cylinder and mixed in ejector with water from main. Mixture applied to main through soln. tube. 25 lb. of chlorine per hr. have been applied at ordinary temps. from 150-lb. cylinders. Higher rates possible when cylinder heated. Complete operating instructions included.—*F. J. Maier.*

Sterilization of Water Mains and Emergency Water Supplies. G. F. RENTON. J. Roy. San. Inst. (Br.) **62:** 33 (Jan. '42); Wtr. & Wtr. Eng. (Br.) **45:** 10, 70 (July, Aug. '42). Most convenient way of sterilizing small mains by application of sodium hypochlorite. Water in pipe should receive concn. of 50 ppm. of chlorine. Bleach powder should be kept in air-tight drums and stored in cool, dry place. Sodium hypochlorite soln. loses concn. after a time. Not advisable to keep large quants. in stock. Choice of methods to sterilize mains include portable chlorinator, sodium hypochlorite and bleach powder. First most accurate and efficient; second can be used either by pouring soln. through ferrule hole or in hydrant. Essential that main charged with water at predetd. rate of flow and chlorine soln., of known strength, injected into main uniformly at point upstream of length of main to be sterilized. In sterilizing large mains, they should first be emptied and thoroughly flushed. Found convenient to inject soln. into main through hydrant on which suitable connections made to receive injection tube. If necessary to distribute water by mobile tanks, advisable to chlorinate water in tanks for first few journeys. Survey should be made of all possible sources (of water) in dist. and scheme prepd. to put it into operation when occasion demands. Unpleasant taste imparted to water by 50 ppm. of chlorine can be removed by addn. of sodium thiosulfite. *Discussion.* E. F. W. MACKENZIE: Exception must be taken to statement that 50 ppm. of chlorine will render water safe for domestic purposes. Waters which contain particulate infective material not susceptible to purif. by chlorination alone. Interruption of water carriage systems of sewage disposal will inevitably result in poln. by excremental matter of many surface waters. H. K. SMITH: One water distr. official has taken author's language to mean that poln. will work its way into main against pressure and scouring action of flowing water. Such conclusion would mean drastic revision of previous ideas on value of water as cleansing agent. Seems reasonable to assume poln. mentioned by author took place some time during making of repairs.—*H. E. Babbitt.*

Chlorination of Polluted Tidal River Water With a View to Its Use for Emergency Drinking Purposes. C. J. REGAN. J. Roy. Inst. Pub. Health Hyg. (Br.) **5:** 95 ('42). Filtered river water treated with 60 ppm. Cl showed no coliform organisms after 30-min. contact. 4-hr. contact period necessary when Cl dosages of 3 ppm. employed, owing to ammonia-N present. Unfiltered samples could not be safely treated. The break point of the water was 20–30 ppm. Cl applied for 30-min. contact period.—*C.A.*

A Carbon Carrier for Oligodynamically Active Silver for the Disinfection of Water. P. S. HARRIS, A. GOETZ & R. L. T. PASADENA. Phys. Rev. **60:** 162 ('41); Kolloidzschr. (Ger.) **97:** 244 ('41). Carriers for oligodynamically active silver formed from small cylinders of lampblack impregnated with silver nitrate. Impregnated cylinders dried in air, then heated in muffle furnace, by which process reduced form of silver produced on carbon. "Activation" of silver accomplished by electrolytic process in which cylinder acts as anode. Cylinders then washed and dried. Final product not affected by moisture and can withstand heating up to temp. of 300°C. When prepn. used to treat water so as to yield about 0.5 ppm. silver in water, water rendered free from bacteria and odors.—*W.P.R.*

Germicidal Detergents. HALVOR O. HALVORSON, ERLING J. ORDAL AND JOHN L. WILSON (to Economics Lab., Inc.). U.S. Pat. 2,263,948. Soap & San. Chems. **18:** 5: 61 (May '42). Germicidal detergent contains buffer salt with Cl_2 contained, disinfecting compd. such as azochloramide and wetting agent, all water soluble. Soln. made to contain 0.5–3% of compn. and is active germicide as well as detergent.—*Ralph E. Noble.*

SWIMMING POOLS

What the Laboratory Means to the Swimming Pool. A. JOHN HORN. Beach & Pool **15:** 9: 17 (Sept. '41). Trend among pub. health officials to demand pool water meet same rigid bact. stds. as good drinking water. Bact. reports should be interpreted in terms understandable by pool operators. Coliform organisms present represent contamn. from bathers and indicate possible potential infection from intestinal pathogenic bacteria, but not types associated with eye, ear and respiratory infections often attributed to swimming pool contact. Better index of contamn. in pools needed. Agar count alone not indicative of any specific organism, infectious or otherwise, nor is coliform index alone sufficient. Certain streptococci strains will and do overgrow coliform types. Investigated Perry modified Eijkman method of *Esch. coli* detn. In 98% of cases, latter grows at 44.5°C. (tube temp.) in 48 hr., compared with *Std. Methods* tubes. Perry-Eijkman (P-E.) test appears more effective than std. coliform test. When *Esch. coli* present, can be reported as intestinal coli to pool operator. Colonies from agar plates should be isolated and identified. P-E. method, compared with A.P.H.A. separation methods, checked accurately and much simpler for routine work. Loop transfer from pos. gas tubes into Eijkman, and direct inoculation from original sample to Eijkman, compared closely enough to permit selecting either technic in P-E. method.—*Ralph E. Noble.*

The Swimming Pool Replaces the Old Swimming Hole. J. HENRY L. GILES. Conn. Health Bul. **55:** 201 (July '41). Concrete swimming pool replacing old swimming hole because of sewage poln. of streams, lack of proper supervision resulting in drowning of persons and inadequate flow of water to handle poln. of 100–1000 bathers. Joint com. of Am. Pub. Health Assn. and Conf. of State San. Engrs. set definite stds. for constr. and operation of pools and detn. of bathing loads for various types of pools. In pools with const. overflow and periodic disinfection, bathers load should be limited to 1 bather per 500 gal. of disinfected water; in pools with continuous chlorination so as to maint. 0.4 ppm. chlorine residual, 1 bather per 40 sq.ft. of pool area; and in pools having continuous chlorination and recirculation system for turning over contents of pool in 6–8 hr., 1 bather per 27 sq.ft. of pool area. Green algae can be controlled by excess dosage with chlorine, but most positive method is use of copper sulfate, 2–4 lb. per mil.gal. for recirculation pools. Other stds. controlling safety of pools also set up by this com. Any new pools with controlled water supply must be approved by State Dept. of Health.—*P.H.E.A.*

Swimming Pool Chlorination. ANON. Beach & Pool **16:** 8: 6 (Aug. '42). During first few moments of immersion in pool, bather sheds millions of organisms. Pool untreated after 1 bather may constitute health hazard. Cl concns. greater than 0.5 ppm. irritate eyes; less than 0.2 ppm. may be dangerous. In fill-and-draw pools without disinfection, 900 gal. of water per bather necessary if pool not emptied for 12 hr. If bathing load greater, 0.3 ppm. residual Cl_2 should be maintd. Should disinfect water daily and keep bathing load ratio of 1 : 140 gal. In recirculating pool, with residual Cl_2 kept between 0.2 and 0.3 ppm. and water replaced every 8 hr., ratio 1 : 50 gal. Methods of chlorination with commercial products described. Algae control accomplished with copper sulfate at 0.25 ppm. or 2 oz. per 30,000 gal.—*Ralph E. Noble.*

The Time Factor in Chlorine and Chloramine Disinfection of Contaminated Swimming Pool Water. EMIL T. CHANLETT & HAROLD B. GOTAAS. Am. J. Pub. Health **32:** 355 ('42). Results of series of observations at 2 public outdoor pools and in exptl. tank under varying Cl and chloramine dosages indicated: (1) high correlation between swimmer load and bact. counts; (2) threshold of Cl_2 disinfection between 0.10 and 0.25 ppm., above which effective bactericidal action obtained; (3) addn. of NH_3 results in loss in concurrent disinfection, which is pronounced at Cl_2 residuals as high as 1.0 ppm. 13 refs.—*C.A.*

The Cleaning and Disinfection of Pools. PAUL HUEDEPOHL. Beach & Pool **16:** 7: 16 (July '42). Expt. with liq. sodium hypochlorites for cleansing pools indicated them better and of quicker action than strong acids. Reduces scrubbing to practical min., does not injure cement or paint finish, elims. possible porous conditions. Procedure described.—*Ralph E. Noble.*

Sterilizing and Purifying Water in Swimming Pools. KURT PIETZSCH (*to Buffalo Electro-Chemical Co.*). U.S. Pat. 2,271,895 (Feb. 10, '42). Method employed which involves chlorinating entire water present in pool to high concn. of Cl suitable for complete sterilization while pool not in use, that is, 0.3–0.7 g. Cl per cu.m., thereafter eliminating excess Cl by addn. of H_2O_2 and then sterilizing while pool in use by continuously adding Cl and then H_2O_2 to small portions of the pool water and adding this to pool, while at same time withdrawing addnl. portion for such treatment.—*C.A.*

Studies of Bathing Beach Waters of Cleveland. PAUL VAN GIESON. Ohio Conf. Sewage Treat. **15:** 39 (Sept. '41). Bact. study of 7 bathing beaches on Lake Erie adjacent to Easterly Sewage Treat. Plant conducted over period of 4 yr. Beaches sampled and anald. according to standardized program and yearly avgs. compiled to total count at 37½°C. and coliform M.P.N. Study showed that considerable reduction of bacteria concn. of lake water obtained due to institution of treatment facilities and that plant effluent had sterilizing effect on bacteria already present in lake. During 3 yr. in which treat. plant operating, 91% reduction in poln. of bathing beach waters effected. Present bact. content within upper limits of that recommended by New York City for bathing waters.—*P.H.E.A.*

Algae Control. ANON. Beach & Pool **16:** 9: 15 (Sept. '42). Algae control one of most common, perplexing outdoor swimming pool problems. Free floating algae give distinct green color to water; clinging type grows on sides and bottom of pool. Latter type more resistant to treatment if allowed to accumulate. Algae growth removes CO_2 from water, resulting in pH increases from 7.5 to 8.0, within few hours, usually before growth visible. Immediate treatment prevents further development and illustrates need for daily tests. Growth produces turbidity which increases safety hazard, bact. content and spoils appearance. Chlorine treatment in large amts. satisfactory, provided pool not used until Cl content reduced to proper concn. by de-chlorination, added make-up water or idleness. Initial dose of 20 lb. of copper sulfate recommended, subject to variation in given cases. Better to apply whole amt. by bag-feed at once, rather than continuously over long period. Danger to swimmers negligible. Frequent brushing of pool sides and bottom helps prevent algae growth.—*Ralph E. Noble.*

The Possibilities of Systemic Infection With Dermatitis-Producing Schistosomes. LAWRENCE R. PENNER. Science **93:** 327 (Apr. 4, '41). Attempt made to answer question: "Can dermatitis-producing schistosomes cercariae (cause of swimmers' itch) continue their development and set up a systemic infection in man?" Author quotes experiences of Bracket (Am. J. Hyg. **31:** 49 ('40)) in exposing

young female rhesus monkey to cercaria of *Schistosomatium douthitti* and results of following autopsy. Outlines in some detail results of 3 similar expts. In first of these expts., young rhesus monkey given cercarial baths over 2-wk. period. Autopsy 4 wk. later negative for schistosomes. In second expt., rhesus monkey exposed for 1 hr. to 24-hr. output of 28 snails. Estd. 28,000 cercaria present. When second monkey autopsied 5½ days later, worms found in lungs and slight hemorrhage noted. Bottle contg. 400 cercaria inverted on abdomen of third monkey. No conclusive evidence obtained from this expt. as no autopsy performed. In all 3 monkeys, physical distress and marked dermatitis observed. In conclusion, author indicates that cercaria douthitti might possibly penetrate skin of man and migrate to lungs. Possibility of mech. transmission of infection also outlined as public health hazard not yet recognized, particularly where swimming or wading done in infected areas.—*P.H.E.A.*

Studies of *Neisseria catarrhalis*. M. W. JENNISON, G. O. TAPLEY & JULIA C. SULLIVAN. (*Published in abstract only.*) J. Bact. **43:** 100 (Jan. '42.) Further investigations of physiology of *N. catarrhalis* made in connection with use of this nasopharyngeal organism as index of swimming pool poln. (*see* Jour. A.W.W.A. **34:** 147 (Jan. '42)), and as possible index of bact. qual. of air. Organism usually isolated on Bacto heart-infusion agar (pH 7.4) contg. 0.025 g./l. phenol red indicator (aq. soln.) and 5 g./l. glucose. On this "presumptive test" medium *N. catarrhalis* produces pH 8.0+ in 18–24 hr. at 37°C., surface colonies being surrounded by intense red area. While glucose, like other sugars, essential for alky. production, presence stimulates growth and enhances reaction. Colonial morphology, Gram stain and biochem. reactions also used to characterize organisms. Many strains otherwise typical showed, even immediately after isolation, neg. oxidase reaction. Cultures oxidase-pos. when freshly isolated, often lose this character upon aging. With newly isolated organism, characteristic diplococcus morphology and Gram-neg. may, for some time, be variable in cultures more than 24 hr. old. All strains rapidly produced alky. on agar in presence of sugars commonly used for differentiating species of genus *Neisseria*. None of strains formed indole or nitrites, and all able to grow at 22°C.—*Ralph E. Noble.*

PLUMBING AND CROSS-CONNECTIONS

The New Detroit Plumbing Code. L. GLEN SHIELDS. Plumbg. & Heatg. Bus. **5:** 8: 12 (Mar. '43). After 6-yr. research in plumbing lab. operated by Detroit Dept. of Bldgs. & Safety Eng., city now ready to enact new plumbing ordinance. In addn. to usual venting requirements designed to maint. trap seals, code contains tables on recommended pipe sizes, capacities and friction losses which prevent back-siphonage in waterlines. Restrictions on cross-connections and introduction of chems. for rust inhibition included. Because of relatively soft water from Great Lakes, max. factors of safety used in specifying pipe sizes unnecessary. One section of code permits temporary use of substitute material during emergency period with reversion to normal code provisions when hostilities end. Before adoption, 16 public hearings held.—*F. J. Maier.*

Emergency Plumbing Standards. ANON. Domestic Eng. **159:** 3: 48 (Mar. '42). Emergency plumbing stds. for defense housing supersede local plumbing codes for practically all residential constr. in hundreds of defense areas. Effective in privately-financed defense housing as well. WPB does not *directly* override local or state plumbing ordinances. Merely grants no priorities for materials entering defense housing unless conforming to stds. Objective to conserve critical materials, yet provide adequate health protection. When conflicting with local codes, latter may be changed or ignored, or above stds. adopted "by reference" by cities involved. Main points covered under vents and venting are: material; protection of trap seals; stack vents required; vent stacks required; distance of trap from vent; dual and group vents permitted; main vents, size and length; size of back and relief vents; frost closure; and vent terminal location.—*Ralph E. Noble.*

An Analysis of Sanitary Facilities in the United States. J. M. DALLA VALLE & ROLLO H. BRITTEN. U.S. Pub. Health Rpts. **57:** 1604 (Oct. 23, '42). Report summarizes data on san. (toilet) facilities collected in Natl. Health Survey, '35–'36. Dwelling units cov-

ered confined to households with at least one person related to head. Urban areas data reflect accurately conditions in urban communities generally. Rural data, however, definitely represent only counties for which information available. 14% of urban households included were without private inside flush toilets; more than half (8%) used privies. Smaller cities show much larger percentages. South fared worse than rest of country. Colored households there showed highest percentages. Close relation existed between type of san. facility and rental (or value). Certain data for rural areas.—*Ralph E. Noble.*

Cross-Connections Between Potable Water Supply Systems and Sewerage Systems. J. R. HOFFERT. Sew. Wks. J. **14:** 3: 604 (May '42). More common cross-connections found in sewage treatment plants are flushing water pipes in sludge hoppers of Imhoff tanks, water seals on stuffing boxes of sewage and sludge pumps, water connections to Venturi meters, Parshall flumes and float chambers for flushing purposes, outlets for flushing sludge piping, digestors and pump sumps and connections to sampling lines operating on aspirator principle. Best remedy is gravity tank filled with potable water from above. Individual connections can be made through air-gap, or, if required under pressure, by temporary connection held in operator's hand. If possibility of contamn. exists, always the chance that possibility will become reality.—*F. J. Maier.*

Cross-Connections in Plumbing and Water Supply Systems. *The Contamination of Water Supplies and Methods of Corrections and Elimination of Cross-Connections From the Plumbing System.* A. A. KALINSKE. Wis. State Bd. of Health (rev. '41). Purpose to assemble under 1 heading and present all-important problem of cross-connections in plumbing system, in simple terms easily understandable by one unacquainted with hydr. eng. Evils of cross-connections must be eliminated. If avg. citizen made to realize possibility and dangers therefrom, plumbing supervisors enforcement of regulations facilitated. Designers and mfrs. must discontinue mfg. potentially unsafe fixtures and appliances. Contamd. drinking water dangerous. To show clearly how back-siphonage and contamn. of water supply occur, conditions producing vacuums and zero pressures in supply lines described under "Cross-Connections and Back-Siphonage in the Plumbing System." Then back-siphonage through closet-bowl flush valves discussed and illustrated in detail under "Pollution of Water From Toilets." In "Other Cross-Connections to Be Found in Homes" author discusses under-rim supply fixture, dangers of safe and unsafe water supplies in homes, water-operated cellar drainers and floor drains with water supply connections. Section on "Installations in Industrial and Commercial Buildings" deals with fire-protection cross-connection, condenser outlet connection, pump primer, bar and soda fountain equip., restaurant dish-washer and other types of submerged inlets and direct cross-connections. "Hospital Equipment" includes under-rim supply fixtures, bed-pan washers, slop sinks, bidets, water filter and sterilizer, instrument sterilizer, aspirator and dental lavatory. "Other Types of Cross-Connections" includes drinking fountains, piping to swimming pools, lab. equip., chlorinator, frost-proof hydrant and air-conditioning equip. Remaining sections: Helping Prevent Water-Supply Pollution by Proper Operation, Maintenance and Design of the Water Supply Piping System; Discussion of Testing of Vacuum Breakers and Other Back-Siphonage Preventors, Fixtures and Devices Eliminating Cross-Connections; Requirements and Policy of Wisconsin State Board of Health Regarding Plumbing Fixture Cross-Connections; The Wisconsin State Plumbing Code [as applied to auxiliary intakes, bypasses and cross-connections; Wis. well constr. code.]; and Vacuum Breakers and Anti-Siphon Devices Meeting Wisconsin State Board of Health Requirements.—*Ralph E. Noble.*

Protection Against Cross-Connections. ANON. Weekly Bul. Calif. State Dept. of Pub. Health **21:** 105 (July 25, '42). Calif. Health Dept. adopted resolution for protection of water supplies against poln. due to cross-connections with auxiliary or emergency supplies. Recognized that under emergency war conditions many may prove highly disastrous to civilian health. Resolution provides that all premises where inferior or pold. water used for fire or indus. use shall furnish and equip independent piping system for drinking or domestic use, that inferior system shall be painted or marked plainly so as to identify pold. water system. Also required that any dangerous water that may be contemplated for use shall be reported to health dept. in advance before any constr. has taken place so that appropriate measures may be taken to protect health of pub.—*P.H.E.A.*

Study and Application of Injectors. C. HERTER. Monatsbulletin (Swiss) **22:** 103 (May '42). Study of injectors for fountains made to det.: (1) pressure of actuating water in upward flow of apparatus; (2) flow of actuating water or supply of water; (3) amt. of water aspirated and flowing back; (4) total el. of water (not over 14 m. in this study). In app. used, lower level of water kept const. by float valve. Vol. of input detd. by calibrated meter, output measured in calibrated container and pressures measured by std. manometers. Both submerged and non-submerged injectors used. Operation of these injectors similar to that of water operated aspirator pumps and well-known. Flow of actuating water found to depend only on upward pressure. Not influenced by variations in height of return flow. In spite of large no. of observations, rather difficult to obtain flow-pressure curve due to turbulent flow of water in curved effluent tube. In submerged apparatus, protective screen had to be taken into acct., but curve nevertheless detd. with sufficient approximation. For given height of return flow, amt. increased rapidly for small pressure variation, then reached critical value at which it tended to stabilize itself, since turbulence at higher pressures tended to impede increased flow. For given pressure, aspirated flow either smaller or greater than amt. of actuating water, depending on height of flow, but amt. aspirated never exceeds twice amt. of actuating water. Under pressure of 5 atm., used here, and for height of return flow of 0 to 1 m., amt. aspirated twice amt. of actuating water; for 4 to 6 m., equal to amt. of actuating water. Use of injectors effects great economy of water without sacrificing desired effect. Injector may be placed in supply pipe or in discharge orifice of fountain to aspirate part of water in basin. Installation in fountain in Vevey, Switz., has three pipes supplying 70 injectors of special type mounted in small circle. Actuating water allows elevation of water in basin and also produces emulsification to give effect of white water. Total flow of actuating water 800 l./min. increased by aspiration by injectors to 2400 l./min. of water elevated.—*Selma Gottlieb.*

STREAM POLLUTION AND ITS CONTROL

Ohio River Pollution Survey: Supplement D—Industrial Waste Guides. U.S. Public Health Service ('42). Final report to Ohio R. Com. comprised 11 indus. waste guides: brewery, cannery, coal washery, coke, cotton, distillery, meat, milk, oil, paper and tannery. These summarize information available on poln. problems related to various classes of indus. in Ohio R. basin. Each includes: (1) *abstract* of essential features; (2) *description of process* covering principal operations; (3) *raw materials and products* enumeration with quant. relationships, including no. of employees; (4) *sources and quants. of wastes*, discussing waste-producing operations and estg. quants. from individual process and total indus.; (5) *character of wastes*, presenting anal. results of individual process and total composite wastes, discussing important characteristics; (6) *poln. effects* with principal objections to discharge of each waste to streams; (7) *remedial measures* with corrective measures involving within-plant recovery practice and waste disposal other than to sewer, treatment practice or in various stages of development, (8) *bibliography;* (9) *note-taking form* for data from indus. plants; (10) *inspection report* as prepd. by field engr. from note-taking form; (11) *flow diagrams* illustrating indus. process steps, waste flows and recovery practices. Guides assist: (1) in work of field engrs.; (2) in estg. strength, vol. and sewered pop. equivs. of indus. discharges; (3) in detg. indicated remedial measures and costs; (4) in soliciting unpublished information from engrs., chemists and others familiar with specific indus. wastes. Basic information on indus. wastes, including remedial measures, obtained from: (1) published literature; (2) private communications with engrs., chemists, munic. and private equip. mfrs., indus. management, trade assns. and others; (3) sampling and gaging results in present survey; (4) field engrs. reports on routine inspections in present survey; and (5) U.S.P.H.S. files. *Survey methods:* Std. procedure by inspection and report, using classified indus. form (I-1 to I-12) or misc. (I-M) "note-taking form" and std. form of report shown back of each guide. At unique plants or those not comparable with others, samples collected for examn. and measuring or estg. flows. In no. of cases, samples of individual discharges collected at point of waste creation. Accurate information usually available on quants. of intermittent discharges, whereas sampling of total plant discharges dild. by

cooling and other waters would necessitate careful, long-time gaging and composite sampling. 2- to 10-day gaging studies made on several typical and unique indus. Special effort made to select those willing to supply detailed operating data covering period, so that gaging and anal. results correlated with plant operations. *Sewered pop. equivs.:* Objectionable indus. wastes may contain: high org. or B.O.D. content; suspended solids; chems. toxic to aquatic life; excess acid, hardness or salinity; taste- and odor-producing substances; undesirable coloring matter. Although no single measure of poln. applicable to all indus. waste types, B.O.D. most nearly satisfactory. Sewered pop. equivs. based on 0.167 lb. of 5-day, 20°C. B.O.D. per capita per day. In few cases, such equivs. based on suspended solids considered. Of interest to plants discharging to munic. treatment plants, particularly plain sedimentation, where sludge quants. important. Per capita contribution of suspended solids taken as 0.2 lb./day. *Remedial measures:* Indus. waste poln. reduction generally accomplished by one or more of following: (1) Changes within plant itself: May involve re-use of all or part of waste within plant, development of by-products, changes in plant processes, or merely greater care in plant operation to reduce amt. of waste discharge. (2) Treatment with munic. sewage: Many wastes effectively treated thus. Pretreatment at source often necessary, or segregate certain portions within plant and exclude from munic. sewers to prevent damage to structures or treatment processes. (3) Treatment in special indus. waste treatment plant: Most plants use principle of sedimentation for removing settleable solids. Method (1) usually most economical and commonly used. Some poln. remains and some expense involved. Method (2) simplest from indus. standpoint and most satisfactory for admin. of poln. abatement programs. Reduces no. of possible sources of poln. and concentrates responsibility for effective waste treatment. Usually necessary to make special provisions in design of munic. sewage treatment plant if appreciable amt. of indus. waste to be treated. Subsequent changes in indus. waste load sometimes causes difficulties. Method (3) used when (1) insufficient and (2) impractical. Separately collecting highly offensive concd. materials or wastes for special attention, utilization or recovery often reduces poln. at great savings over treatment costs. Chem. pptn. popular in indus. waste treatment due to its ability to operate unaffected by greatly varying loads and toxic materials and to lesser capital cost compared to biol. processes. Where removal of settleable solids sufficient, problem not difficult, but satisfactory methods for relatively complete removal of B.O.D. available only for such common wastes as those from breweries, meat plant, milk plant and some canneries and distilleries. Pressing need for more efficient and economical relatively complete treatment of other types of wastes.—*Ralph E. Noble.*

Investigation of the Pollution of the Androscoggin River and Remedial Measures. Maine San. Water Bd. *Bul. 1* ('42). Androscoggin R. 200 mi. long with several large tributaries. Drainage areas 3470 sq.mi., 2090 above Rumford. Watershed sparsely settled. Numerous industries along stream mfr. cotton goods, pulp and paper. Lewiston, 40,000 pop., largest municipality on drainage area. Avg. slope 61 mi. upstream approx. 6′ per mi. Annual rainfall about 40″. *Pollution:* River seriously pold. from Berlin, N.H., to Brunswick, Me., 135 mi., by indus. wastes and munic. sewage discharged without treatment at various points. Other minor poln. sources exist in main river and tributaries. Obnoxious odors emanate during summer. Approx. 96% of present poln. reaching main river due to indus. wastes. Approx. 92% derived from pulp and paper mills. 71% in form of concd. sulfite mill digester liquors separable from other wastes. *River Poln. Capac:* Considering value of stream for disposal of wastes and sewage *vs.* hazard to pub. comfort and health, conclude river should not be pold. to point of pub. nuisance but, at present, impractical to reduce poln. to extent of making river below Berlin fit for fishing or recreational purposes. Propose criterion for poln. control, at all times at all points, be maint. at approx. 2 ppm. D.O. This will not support fish life but will elim. putrefactive odors. Usual O_2 resources and factors influencing its deg. of soln. discussed. Estd. avg. of 135,000 lb. of O_2 per day absorbed from air between Berlin and Brunswick to replace O_2 loss by poln. with substantial excess. Nature of B.O.D. and influencing factors discussed. Tables show O_2 deficits likely to occur from June to Oct. inclusive, while over yr., available O_2 about equals demand. *Remedial Measures:* Std. of 2 ppm. D.O. at and above Brunswick not met in recent summer months, and previously mentioned objectionable con-

ditions prevailed. Primary purpose of investigation to study remedial measures, present cost ests. thereof and det. satisfactory and econ. soln. Constr. of sewage treatment plants, elaborate plants or unproved processes for indus. waste treatment, or storage reservoirs for diln. water, not recommended. Recommend sepn. of concd. sulfite process digester liquors at 3 large paper companies and bldg. lagoons for storing concd. wastes during month of high temp. and low streamflow, until cold weather and high streamflows adequate to provide satisfactory diln. Further recommend co-op. action by industries in co-ordinated regulation of river san. conditions under direct supervision of san. engr. and under general supervision of Maine Sanitary Water Board so far as its authority permits.—*Ralph E. Noble.*

A Study of the Stream Pollution Problem in the Roanoke, Va., Metropolitan District. P. H. McGauhey, H. F. Eich, Herbert William Jackson & Croswell Henderson. Va. Poly. Inst. *Bul. 35* (May '42). Investigation made of poln. characteristics of Roanoke R. as of June '40 to May '41, some 22.5 mi. of river from upstream of Salem to about 14 mi. downstream from Roanoke, being included in survey. Above Roanoke, river has drainage area of 388 sq.mi. Wastes, present to signif. deg., included domestic sewage contributed by pop. of approx. 100,000 and indus. wastes from tannery and large viscose rayon plant. Data presented supporting conclusions that river unfit for recreational purposes, detrimental to fish life and injurious to hydr. machinery, and that indus. wastes produce greatest pollutional effect on stream chemically and physically, while domestic sewage most important bacteriologically. Some recovery of stream evident at last sampling station downstream, particularly in D.O. content, to lesser deg. in nitrates present and plankton indicators of poln., but to no evident deg. from standpoint of bact. poln. Report divided into 2 parts: *Part 1* deals with physical and chem. test of waters, san. bact. examn. of waters and plankton of waters and muds. Presents graphically and in tabular form results of 8 weekly field and lab. chem. tests and 18 addnl. anals. made at monthly intervals, latter including bact. examns. and particularly complete planktonic studies. *Part 2*, dealing with microscopic invertebrate and vertebrate faunae and toxicity of viscose effluent to fishes, reveals incident of vertebrate and invertebrate faunae correlated with observed characteristics of stream.—*P.H.E.A.*

Suggestions for Prevention of Pollution of Waters by Oil Field Wastes. Ill. Dept. Pub. Health & San. Water Bd. (Rev. '40). *Powers and Duties of Board. Poln. Defined:* Duty to study, investigate and det. ways and means of elimg. from state streams and waters all polg. substances and materials; also to det. methods of preventing poln. detrimental to pub. health or health of animals, fish or aquatic life, or detrimental to practical use of waters for recreational purposes. Waters pold. if qual., after reasonable treatments, impaired for pub. supply, bathing or recreational purposes as result of liq. or solid substances discharged therein; provided waters reasonably capable of serving said purposes before. Also considered pold. if obnoxious odors result from such discharge near bldgs., roads and lands occupied or used by humans, unless bd. determines discharge legal. Also pold. if qual. impaired for livestock use, kills or injures fish life when waters previously practical for said purposes. *Suggestions for Poln. Prevention by Oil Field Wastes:* (1) Provide slush and reserve pits of adequate capac. and constr. located so as not to receive surface drainage; (2) use oil saver when swabbing wells and swab oil into tanks whenever possible; (3) prevent oil overflow from flush pits when swabbing well into pits; (4) block off oil, mud or other waste from well out of control, permitting none to enter creeks, rivers or lakes; (5) remove oil from slush pits and fill upon completion of well; (6) promptly repair all leaky pumps, stuffing boxes, lines, tanks and connections; (7) drain all oil from wet strings of tubing to a pit; (8) keep all well cellars and other oil sumps pumped out; (9) prevent escape of oil drained from bleeder valves or spilled at loading racks; (10) provide fire-walls of satisfactory capac. and constr. around all tank batteries and other oil storage tanks; (11) use only approved type rainwater drain through fire-wall; (12) use pipe or diked ditch to carry B.S. [*sic.*] from storage tanks to burn pit; (13) provide satisfactory burn pit or sump for collection and disposal of B.S. drained from storage tanks; (14) keep all ditches and pits cleaned and repaired; (15) sub-surface brine disposal most satisfactory disposal method in Ill.; (16) solar evapn. of brine unsatisfactory in Ill. except as temporary expedient; (17) brine disposal by

controlled diln. practically no application in Ill.; (18) construct brine lagoons so they will not receive surface drainage or allow seepage; (19) keep leases clean. Continued objectionable poln. will constitute just cause for taking definite action against offenders in accordance with San. Water Bd. law.—*Ralph E. Noble.*

Oil Pollution at Norco. ANON. La. Conservationist **1**: 5: 6 (Apr. '43). Ordinary sepn. methods failed to remove nitrogen bases and acid oils formed as waste product at petroleum refinery and allowed oxygen depletion, odors and unsightly banks in receiving stream dug as borrow pit for important highway. Neutralizer, to break emulsions by agitation with steam, and 2 new oil-water separators, all costing at least $29,000 installed, prevented further poln. reaching stream, excepting algal clusters, which grow in separators, occassionally dislodge and carry small amts. of oil. Accumulated sludge deposits, contg. 30,000 ppm. oil, still keep stream foul; their removal by dredging stopped as danger to nearby roadbed. Tank car washings, contg. molasses, edible oils and petroleum from another plant in vicinity found to reach stream through overdrained separator pit, otherwise adequate.—*A. A. Hirsch.*

A Revolution in Pickling Methods. A. MCLEOD. Sheet Metal Indus. ('40) p. 715. Description of de Lattre process for pickling metals used at some Belgian factories. In process, discharge of waste pickling solns. avoided, and poln. of rivers and streams elimd. Action of pickling ferrous metals in sulfuric acid dissolves oxides of iron from surface of metal and ferrous sulfate formed in soln. Content of sulfuric acid in bath therefore decreases and content of ferrous sulfate increases. In usual processes, when content of ferrous sulfate reaches about 300 g./l., bath discharged to waste or regenerated by cooling so that crystals of ferrous sulfate separate out. Disadvantages of pickling with sulfuric acid are that high temp. necessary, deposit of carbon retained on pickled surfaces and, as content of iron salts increases, deposit of partly dehydrated ferrous sulfate formed on metal. Pickling with hydrochloric acid more costly than with sulfuric acid, but preferred at some works as it can be worked at lower temps. Pickling with hydrochloric acid continued until nearly all free acid disappears. To regenerate soln., temp. raised to 50°C. and sulfuric acid added so ferrous sulfate and hydrochloric acid formed. Ferrous sulfate then partly removed by cooling mixt., but amt. in liquid gradually increases with successive regenerations. Qual. of pickled product may be adversely affected by absorption of hydrogen in metal; dangerous fumes of hydrochloric acid produced. In de Lattre process, pickling soln. contains ferrous sulfate, hydrochloric acid and sulfuric acid. Ferrous sulfate and hydrochloric acid react to produce sulfuric acid and ferrous chloride, responsible for pickling action of soln. Ferrous sulfate removed by fractional crystn. when its concn. becomes too high. Sulfuric acid consumed in pickling process and only very small quants. of hydrochloric acid must be added. Gelatin, peptonized by hydrochloric acid, used as inhibitor. Liquid in washing tank soon becomes weak pickling soln. and, after used liquor regenerated, fraction of washing bath used to make up vol. of pickling soln. Use of this process at 2 works in Belgium described. Incrustation in cooling system negligible. Before war good market for cryst. ferrous sulfate recovered. Possible uses for ferrous sulfate include production of pigments by pptg. iron hydroxide by means of zinc oxide, and mfr. of sulfuric acid by direct decompn. of ferrous sulfate by heat. At one rolling mill in this country, annual consumption of acid 280 tons; estd. that if de Lattre process introduced, annual consumption of acid reduced to 196 tons. (*See also* following abstract.)—*W.P.R.*

A Critical Discussion of the Data Provided on the de Lattre Processes. Sheet Metal Indus. ('40) p. 829. Criticism of claims put forward for de Lattre process of metal pickling (*see* preceding abstract). Reason to believe it is mainly hydrochloric acid which is destroyed in pickling, as it is the more active acid and as the speed of the process and the cleanliness of the pickled surfaces are typical of hydrochloric acid pickling. If this is so, then process nothing more than regeneration of hydrochloric acid with sulfuric acid. Use of inhibitor not confined to de Lattre process. Probable that, where large savings in consumption of acid reported due to adoption of de Lattre process, they are essentially due to use of inhibitor. If water in washing tank allowed to approach concn. of weak pickling soln., further washing will be necessary so that addn. of part of contents of first washing tank to pickling tank will not elim. problem of dis-

posal of waste washing water. Economics of processes for recovery of copperas require careful study, since, if ferrous sulfate not to be crystd. out, concn. of sulfuric acid can be allowed to fall to lower figure. In de Lattre process, ferrous sulfate recovered likely to contain traces of chloride.—*W.P.R.*

Treating Pickling Liquors for Removal of Toxic Materials. GEO. E. BARNES & MATHEW M. BRAIDECH. Eng. News-Rec. **129:** 496 ('42). Acid pickling liquors incidental to cleaning and electroplating operations when discharged after neutralization with lime into creek had toxic effect on aquatic life and caused unsightly lime deposits and when discharged into munic. sewer system interfered seriously with digestion of activated sludge. Waste liquors contained Cu, Ni, Cr and CN^-; and examn. of sludge from digestion tanks showed considerable contamn. with sol. chromates and Cu in suspension, together with some CN^-. Lab. expts. confirmed toxicity of constituents on sludge digestion, although apparently certain concns. of Cu after initial retardation of digestion, accelerate it. Metallic ions, with exception of chromates, readily converted by lime into less sol. hydrous oxides and reduction of chromates to chromic form and subsequent removal as hydroxide by lime treatment seemed feasible. Treatment process evolved consists of passing acid wastes through contact bed of scrap Fe to reduce chromates, addn. of separately collected CN^- wastes, treatment with lime to pH 8.4 and sedimentation. Sludge, which contains about 10% Cu, 2% Ni and 20% Cr., disposed of by lagooning. Removal of Cr, Ni and Cu 95% or better. Up to 20,000 gal. of raw acid wastes can be treated per day. Fe turnings are loosened each day by means of a pipe through which compressed air introduced and occasional replenishment of Fe required.—*C.A.*

The Reclamation of Waste Pickle Liquor. J. H. G. WILLAN. Sheet Metal Indus. ('41) p. 487. Description of various methods available for treatment of waste liquor from pickling metals. Liquor contains free acid and ferrous sulfate. 3 main methods available for treating wastes. First method, acid and sulfate converted to sulfur dioxide and then to sulfuric acid; second method ferrous sulfate sepd. from mother liquor and then converted to sulfuric acid; and in third method liquid neutralized and then evapd. for recovery of copperas or discharged without further treatment. In process recently developed, a constructional material known as "Ferron" prepd. Free acid and iron salts neutralized and pptd. by addn. of alkali at controlled pH value and temp. Ppt. passed through filter presses, dehydrated in pug mill and molded to any desired shape. Liquid from filter presses clear and can be re-used or discharged. Capital and operating costs of plants for producing "Ferron" not high and ready market for final product. In plants for reclamation of acid, circulation of free acid introduces corrosion problems. No market for amt. of ferrous sulfate which would be produced if all steel mills recovered this material.—*W.P.R.*

Utilization of Pickle Liquor. F. J. VAN ANTWERPEN. Ind. Eng. Chem. **34:** 1138 (Oct. '42). Booming steel production in wartime increases problem of disposing successfully of millions of gal. of pickling soln. contg. iron sulfates plus acid. Bldg. material called "Ferron" being made from waste pickling liquor by Colton-Rentschler process at Sharon Steel Corp. plant. Has operated 2 yr. and treats about 25 tons liquor daily. Pickling liquor usually contains 17–25% ferrous sulfate and 2–7% sulfuric acid. Collected in storage tank, pumped to 2000-gal. rubber-lined agitation kettle, dild. to 2% acid and filler added, e.g., ground newsprint, asbestos, cinder, clay or wood fiber, to 2–25% by wt. of batch. Then neutralized with slaked lime at temp. above 140°F. After pptn. of iron hydroxide and calcium sulfate, slurry, about 20% solids, filtered on filter presses and reduced to 50% moisture. Extruded from pug mill, cut into desired shape and dried in gas-fired oven at 300°F. In mfg. wall board, wood fiber used as filler and moisture decreased to 25% using 1500 psi. pressure on board press, then air-dried. Effluent from recovery plant claimed not to contam. streams or sewers. pH about 11, iron and heavy metals pptd. and bacteria absent. "Ferron" made of densities from 20–125 lb. per cu.ft. Lighter variety not so strong as denser, but satisfactory for wall board and good insulating properties. Dense variety very strong and can be molded. Color brown. Adding 2% starch increases rupture strength 300%, and 8% asphalt emulsion increases it 500%. 5% asphalt used in practice. Material fireproof and can be sawed, planed or drilled. Nails held firmly. Non-corrosive, takes paint and varnish, can be plastered and does not burn or decay. Can

be waterproofed with 1–2% sodium silicate, a necessary treatment since material weakened by continual soaking or wetting with water. Wet "Ferron" can be mixed with clay about 1:1 and fired without prior drying. No spalling. Light, porous product with much improved heat insulating properties. 500 gal. liquor yield 1 ton "Ferron," costing $9. Several houses built using "Ferron" and no serious drawbacks found.—*Selma Gottlieb.*

Control of Pollution From Sewage Effluents. NORMAN J. HOWARD. Can. Engr.—Wtr. & Sew. **80**: 10: 17 (Oct. '42). Royal Commission on Sewage Disposal, in 8th Rpt., recommended that sewage effluents should contain not more than 30 ppm. of suspended matter and that 5-day B.O.D. at 65°F. should not exceed 20 ppm. Suspended solids as high as 150 ppm. permitted with dilns. up to 500 vols. Also stipulated that receiving stream should have 5-day B.O.D. not exceeding 4 ppm. below outfall in order to maint. satisfactory conditions at temp. of 65°F. under dry-weather conditions. Very few Canadian plants able to produce effluent conforming to such stds. May be due to almost unlimited diln. available in some places. True that cheaper to treat water supplies than to purify sewage, but intolerable situation often created at water purif. plant. In addn., water qual. at bathing beaches often highly objectionable and citizens denied privilege of bathing in water which should be ideal for summer recreation. Problem of discharge of trade waste into sewers also serious problem. Many municipalities cannot demand curtailment of discharge of industrial wastes into bodies of water used as sources of water supply because of fact that municipalities themselves are conspicuous offenders.—*R. E. Thompson.*

Planning Sewage Works for Postwar Construction. *Interstate Sanitation Commission Controls Efficiency of Present Plants and Requires Plans for Future Construction.* SETH G. HESS. Sew. Wks. Eng. **13**: 503 (Oct. '42). Pub. health dominant factor in war effort. WPB and FWA give preference to water supply, then power, fire equip., sewage and access roads, in that order. Interstate San. Com., authorized under N.Y., N.J., and Conn. laws to control and abate poln. in N.Y. Harbor and adjacent waters, can direct those not meeting compact requirements to proceed with works for poln. abatement. Gen. concept incident to policy formation appears to be that where existing poln. does not endanger pub. health, creator thereof should, as soon as possible, prepare complete detailed plans of necessary works for abatement, with complete specifications and financial plan with which to proceed at propitious time or when fed. govt. offers inducement. As part of educational program, Com. recognizes value of inspecting actual poln. conditions by groups. Impressions more vivid and effective than photos or description. Other phases discussed.—*Ralph E. Noble.*

WELLS AND GROUND WATER

State Codes. ANON. The Driller **16**: 6: 6 (June '42). I. All states comprehensively surveyed as to well drilling or constr. code status. Majority intermediate, with codes for drilling, constr. and change of *pub.* supplies, but none clearcut for both pub. and private. Some illustrate capability of health dept. to enforce private water supply stds. in absence of state provisions; e.g., La. san. code provides that plans and specifications for proposed new systems be referred to state bd. of health for approval. This limited legal support made effective by adopting U.S.P.H.S. report on ground water supplies as guide in reviewing requests for new wells. In Ohio every local health dept. [presumably county] in charge of san. regulations for own area. Many local bds. adopted state dept.'s sanitation recommendations for rural and urban dwellings. Iowa, Conn., Ala., Kan., Tenn., Va., Ind. and W.Va. use educational bulletins. In Neb., with almost complete code, pub. water works must meet U.S.P.H.S. stds., while wells in cities or villages must meet state health dept. stds. State sanitation regulations, however, do not provide enforcement for urban wells. In few states having genuine well drilling code for both pub. and domestic water supplies, provisions differ widely; e.g., Ark. code pertains to pub. and semi-pub. water supplies while Minn. specifically states private supplies to large extent, at one time or another, part of pub. *Minn. Manual of Water Supply Sanitation* comprises all different methods of water sanitation in various states, assembling as a unit requirements and other pertinent information for all types and sizes of water systems. Colo. regulations govern well drilling,

pump and water system installations. Bd. of health favors complete codes to aid well drillers. All Fla. waters under state bd. of health jurisdiction. In Utah, well drillers must obtain well drilling license *annually* from state engr. *Ibid.* **16**: 7: 6 (July '42). II. *Wisconsin Code:* Granted clearcut authority to control constr. of wells for private use, state bd. of health set pace in formulating and putting into practice set of rules and regs. keeping private water supplies safe, and important industries stabilized. Its code most comprehensive of all. *Part I.* Begins with full reprint of Wis. statute (ch. 162, "Pure Drinking Water") dealing only with constr. of private wells. Neither sets up stds. nor issues regs., but instructs bd. of health to do both. Extends authority over all well types by defining well drilling as industry and procedure to obtain ground water from well by digging, boring, drilling, driving or other methods, including all constr. work and installation of well casings for protection against poln. Addnl. powers given bd. include: (1) to employ competent supervisor and assts. to supervise and inspect all well drilling operations and aid enforcement of all laws, rules and regs.; (2) to conduct expts. for advancing tech. knowledge and detg. cause of ground water poln.; (3) to inspect all water supplies for human consumption, order corrections and repairs, or discontinuance of any well found contamd.; (4) to require any driller or other person responsible for water supply to have water anald. by state lab.; (5) to prep. and print such codes and bulletins as necessary for pub. health safety and *betterment of the industry;* (6) to provide upon request of any well owner or driller, recommendations for obtaining safe water supply for human consumption. Remaining provisions of act concerned with driller permits and with penalties, law on wasting artesian flow, and list of laws, regs. and codes affecting water well industry. *Part II.* (*Rules and Regulations*) begins with statement of basic principles—where well constructed to supply ground water, safe and fit for human consumption and prepn. of food products, constr. shall be: (1) adequate in size and depth to afford necessary supply of ground water where available; (2) permanent and durable and accessible in location; (3) made in good workmanlike manner, according to approved methods and stds. to give adequate protection against any contamn.; and (4) located in surroundings maintainable in san. condition without undue effort. One section pertains to water anal., requiring same on: (1) completion of newly constructed well; (2) completion of repairs or alterations to well, pumping equip., or well surroundings; or (3) whenever bd. requests. Another relates to pub. water works systems, making clear that well constr. code does not govern design, constr. or equip. of any wells used as part of such systems. Pub. water supply defined as one serving 10 or more premises of mixed ownership. Points out that problem of cross-connections governed by water works and plumbing codes. *Location:* Wells shall be located: (1) at highest point in premises consistent with gen. layout and protected against surface wash; (2) as far removed and in direction opposite to underground flow from any known or probable source of poln. as gen. layout permits; (3) at least 25′ from all sewers, unless latter constructed of c-i. pipe with leaded joints, when min. of 10′ distance to be maintd.; (4) not less than 2′ from all bldgs. and projections therefrom; and (5) reasonably accessible for cleaning, treatment, repair, test, inspection, etc. Wells for drainage purposes forbidden. Protection when under constr., diams., use of screens and liners for drilled wells considerably detailed. Regs. on constr. of bored, driven and dug wells given. After completion, every well shall be sterilized, flushed, tested for yield, sealed watertight and owner notified of completion by driller personally or by letter. Within 30 days after completion, driller must submit to bd., on forms provided: (1) diagram of premises giving location of well with reference to bldgs., cesspools, rivers, lakes and other possible poln. sources; (2) log covering all essential constr. details; (3) owner's name and address and actual location of premises. Permanently or temporarily abandoned wells must be properly filled with specified materials and reported to bd. Well pits not forbidden but to be avoided when possible. Any equip. or appurtenances, permanently installed, shall be joined watertight to well casing at point of entrance. Drilled well power heads mounted substantially over well but not on approved "pitless" pumper units must be certain distances above floor according to type of pump and mounting; must maint. adequate annular clearance around well casing above floor or have base adequately protecting well opening and permitting casing to project watertight above floor to pump base. All pressure systems must have petcock or similar valve between pump and pressure tank for sampling. Hand pumps must be connected watertight

upon base flange attached rigid and watertight to casing. If pumping equip. with moving parts in well below 10', water must be delivered through pipe enclosing parts and distinctly separate from casing irrespective of well diam. All pumping equip. must be protected from freezing by heated pump rooms, approved underground pipe arrangements or drain in pump pipe below frost line. *Part III:* Virtual handbook of instructions for driller illustrates and discusses development of safe well supplies, cement grout, constr. planning, testing casing for leakage, artesian wells, water anal., sterilization, pit elimn., co-op. water supplies and geol. data. Minn. manual, as related to private well constr., contains only information, "principles," and instructions. It uses "*should*" where Wis. code uses "*shall.*" While latter covers only private wells, Minn. manual includes pub. systems. Chief merit, it supports drillers' efforts to sell qual. rather than inferior well constr., educates pub. and discourages unethical drillers. *Ibid.* **16:** 8: 6 (Aug. '42). III. *Conservation:* Mich. code published by Mich. Well Drillers Assn. "in co-op. with" depts. of health and conservation. State has stds. for *pub.* ground water supplies, but no control over private ones. Code includes sections on: wells and constr., pumps and installation, geol. information on water supplies, gen. information and tables. Wis., Minn. and Mich. codes complete and thorough. Not only contain provisions covering virtually every aspect of well constr., but many considerably detailed and illustrated. Fla.'s brief code is chapter of state san. code, incompletely approved as yet by state bd. of health which controls all Fla. waters and, therefore, all well constr. Thus, code provisions have legal force. Code merely a series of gen. rules, details of conformance thereto being driller's responsibility. Utah's approach entirely different being based on conservation of most valued natural resource rather than health protection. Surface supplies being scarce, underground ones needed for irrigation as well as human and animal use. Each yr., drillers must obtain from state engr. non-transferable drilling permit and post $500 penal bond against violation of rules and regs. In addn., no well drilled, repaired, cleaned or deepened until owner receives written approval from state engr. *after* driller files notice of intent, giving complete details, including application no. to appropriate water. Latter gives clue to whole situation. Utah declared all waters above or below ground pub. property, requiring permit for intended appropriation. In addn., necessary to publish notice in newspaper to give neighbors chance to protect rights if encroached. N.M. declared waters pub. property but limits to underground streams, channels, artesian basins, reservoirs and lakes with reasonably detd. boundaries. Appropriation notice also filed and publicized by owner but drillers not compelled to make reports or obtain permits. *Ibid.* **16:** 9: 3 (Sept. '42). IV. *Compliance.* Utah, Wis., Ill. and N.Y. issue water well permits. Purpose of latter is compliance with law. In N.Y., licenses (permits) required only on Long Island where ground waters greatly depleted by overpumping. Water levels seriously lowered and many wells turned salt, giving rise to conservation problem in which drillers must file intent to drill and description of job, with logs after completion. State endorsement gives permission to proceed but under endorsement requiring application, owner must obtain permission. Granting latter detd. by proposed capac., total on one property being limited to 100,000 gpd. In Ill., driller permits issued yearly. Constr. permits required of owner or driller for proposed wells, mainly on water wells for health dept. information. In Wis., permit not required for obtaining ground water supply on owned or leased property, but well and work shall conform to law. Bd. of health approval required on all constr. financed by FHA. In Fla., driller makes application but work not begun until proposed constr. approved by chief san. engr. Cutting samples and logs required after completion. Every state keeps strict control over pub. water supplies, practically all having rules and regs. re constr. of wells for pub. and semi-pub. use. Plans for munic. systems, whether supplied from surface or underground, usually must be submitted to state bd. of health for approval before constr. starts.—*Ralph E. Noble.*

Some Structural Requirements for Sanitary Wells. ANON. The Driller **17:** 1: 3; 2: 6 (Jan., Feb. '43). I. Purity of water from underground sources depends upon adequacy of safeguards of structural part of well. Safe ground water procurement and any scheme for permanently safe well constr. must provide effective means of avoiding poln. and for max. use of natural purifying processes. Under natural ideal geol. and hydrol. conditions, satisfactory water obtained by ***driven point well,*** simplest and cheapest form of

constr. Under these conditions, it provides moderate water supply generally adequate for single family domestic requirements. Pumping from any type of well creates depression in adjacent water level, termed zone of influence. Pumping effect called de-watering. As water enters moving ground water, course of direction changes from downward to horizontal where it remains in upper horizon. If entering water pold. and level near well depressed by pumping, depth of vertical zone of poln. extended directly proportional to amt. of drawdown. Well constructor, therefore, insures water safety by extending watertight constr. to suitable depth below dynamic level. *Bored well* next most economic type, but failure of water supply continual hazard. Bored type usable only in deposits sufficiently stable to allow opening from surface to water-bearing stratum until concrete pipe or similar material installed as curbing. Constr. procedure results in annular space around curbing through which surface and sub-surface water can drain into well. Curbing joints usually not watertight. Placing concrete seal around iron pipe within clay bed below upper gravel deposit prevents pold. water drainage into well. *Drilled well* constr. type best suited to all geol. conditions. Design detd. by following grouped conditions: (1) unconsolidated deposits like sand or gravel reaching to indefinite depths from surface and with yield sufficient to maint. dynamic water level at least 15′ above lower end of casing pipe; (2) stable deposits (clay) overlying water-bearing deposits (sand or gravel) 20′ or more to indefinite depths; static and dynamic water levels unimportant; (3) rock formations within 50′ from surface. Water level importance depends upon character and position of formations. Principles of proper safeguards against poln. when constructing drilled well in unconsolidated deposits same as those relating to driven point well. Casing watertight and extended from suitable el. above permanent grade at well to point *unquestionably* below poln. penetration. Usually at least 15′ below dynamic water level when pumping at max. sustained "in service" rate, plus difference in el. between existing and lowest known water table. Sand and gravel prevent channeling and afford protection. Suitable depths of unconsolidated materials reasonably expected to afford sufficient protection are: fine sand, 20′; coarse sand, 40′; fine gravel, 60′; coarse gravel, 80′–100′; very coarse gravel (?). II. When constructing drilled well in stable (clay, etc.) deposits, annular space about casing unavoidably established. May remain partially open or become enlarged by constant water movement through it. Instance cited. To seal annular space effectively, essential that opening be adequate to depth sufficient to insure proper placing of grout material. Many drillers establish drill hole with diam. at least 4″ larger than od. of casing pipe being installed, depending upon geol. conditions, varying 20′–40′. Some maint. opening until driving operations completed, then sufficient concrete for collar placed at bottom of annular space. Remaining opening filled with puddled clay, usually slurry from drilling operations. In some areas, std. practice to keep large initial opening filled with slurry (drill cuttings) during entire driving operations. These practices reduce no. of newly constructed unsafe wells from 39% to 7% in yr. In 7%, following causes included: (1) insufficient grouting, 10′ or less; (2) improperly placed grout material, annular space too narrow to permit effective grouting and use of unsuitable filler materials; (3) failure to grout below porous near-surface beds receiving drainage from sewers, drains, cesspools, leaching pools, barnyards, etc. Condition serious menace to safety of water supply emphasized with diagram. Any combination of conditions in valving near-surface or dry gravel layer extending to considerable depth and overlying clay bed sufficiently stable to maint. annular opening down to water-bearing deposit or rock, regarded hazardous. In all such cases, annular opening should be effectively sealed below sand or gravel layer. Placing concrete seal within clay or similarly impervious formation below sand or gravel layer requires temporary casing through same. Involves more effort to complete well but desirable health insurance. *Ibid.* **17:** 3: 6 (Mar. '43). III. Lime and sandstone principal aquifers in large sections of country. Many limestone beds nearly flat and frequently intersected by transverse and bedding joints, increasing permeability and water-bearing capac. Important, therefore, that well constructor be alert to possible fracture openings in this formation. Such openings in limestone comparable to systems of innumerable interconnected pipelines of varied sizes in all directions. When principal openings uniformly vertical and horizontal, entering water passes downward to join moving ground-water body. If vertical fractures predominate, water penetrates considerable

depth. With horizontal predominating, horizontal movement several miles possible, as attested when pea hulls pumped from well 9 mi. from disposal point connected with same rock formation. Again, seasonal pumping of a large cannery well seriously affected most wells in same formation at 8-mi. radius. Creamery wastes which entered drainage well terminating in limestone appeared in spring ¾ mi. away. Several recent instances of sewage poln. in wells causing numerous typhoid cases—many fatal. Thus, water movement through fracture systems may be rapid, extend considerable distance and be impure. *Safeguarding Shallow Wells From Poln:* (1) Where rock formations within 50′ of surface, thoroughly fractured and water table high, reasonable safety assured by carrying water-tight (cased and cement-grouted) constr. at least 15′ below well water level when pumpage rate equal to max. sustained probable demand. (2) Where water table or artesian head low (100′ or more) often possible to terminate water-tight constr. in impermeable or comparatively tight formation at 50′ plus, preventing possible unclean water movement from overlying formations to underlying aquifer. (3) Where sandstone formation lies within moderate depth, utmost safety assured at min. expense by terminating water-tight constr. at least 20′ therein, establishing natural filter for all surface water. *Safeguarding Deep Wells:* Most geologic structure favors existence, procurement and maint. of safe ground-water supplies. Most difficulties man-made, e.g., improperly constructed, inadequately sealed, abandoned and drainage wells. Septic tank effluent disposal into fractured rock formations common. When drill hole intersects openings, direct connection established. Unless water-tight constr. extends sufficiently below dynamic water level, sewage pold. water may drain into well. Adverse conditions possible after well in use include gen. lowering of water table or artesian head, heavy pumping from nearby wells, over-pumping of ground-water supply, sewer or sewage disposal installations, adjacent dumping of contamg. wastes and nearby blasting. Remedial constr. usually consists of sealing openings through which unclean or unfit water enters. Because too small well bore hampers required operations, owner should first insist that bore terminating in rock be adequate for remedial constr. Generally should be not less than 6″, to enable setting 3½″ liner pipe with coupling joints or 4″ one with welded or flush joints in cement grout through such part of drill hole below initial water-tight constr. necessary to exclude undesirable water from well. If future deeper drilling of well anticipated, drillable liner pipe in lieu of iron will facilitate regaining full initial diam. of drill hole and, consequently, satisfactory addnl. constr. *Ibid.* **17:** 4: 6 (Apr. '43). IV. Natural filtration of water in course of movement from surface to and within ground-water body not confined to mech. "strainer action." In hard rock formations (granite, slate, quartzite, marble, basalt, etc.) practically no percolation permitted because formations fine-grained and very dense. Nevertheless, sufficient water for small needs may be obtained from cracks and crevices near surface; occasionally substantial supplies found at greater depths and some flowing wells obtained. Ground-water purity depends almost entirely upon filtration and associated purifying agencies. Deg. detd. by soil character, deposits, formations, chem., biol. and other natural forces encountered in course of movement. In relation to ground water, functions of natural filter materials classified as: (1) mech. (strainer) action, separating coarse particles from ground water and (2) sedimentation and accretion, removing bacteria by virtue of retention under influence of diln. and agencies affecting death rate of intestinal organisms. Sand, gravel and sandstone formations natural filters purifying major vol.; clays and similar materials purify only small part of ground-water supplies. To protect shallow wells against poln. in water-bearing sand and gravel deposits by utilizing their filtering properties, essential to know something of involved mechanisms. Grossly pold. water percolates downward through dry zone above water table. Suspended matter including bacteria settles and accumulates on sand grain surfaces. Upon entering ground-water body, partially purified water moves with it. There, further settling and deposition occur while inclusion and adhesion prevent further bacteria transportation. Prolonged sufficiently, processes eventually remove all foreign and polg. material. Thus, retention a function of filter depth, and, as movement of pold. ground water horizontal, adequacy of filter depth detd. by distance between poln. source and well. Porosity of filter also factor. In locations where available supply in relatively thin mantle of unconsolidated materials overlying impervi-

ous deposits or rock formation, natural filtering quals. of local deposits must be fully utilized to safeguard supply. Where hydrologic and geol. conditions permit, water safety primarily sought through adequate depth of watertight well constr., supplemented where possible by natural protection from maintg. suitable distances from polg. sources. Contrary to still prevalent erroneous belief, poln. does not spread in all directions upon entering ground water, but moves with it as gradually narrowing stream. Free ground water moves laterally in direction of water table slope, usually according to gen. land slope. "Probable safe" distances between wells and poln. sources shown in Table 1. *Ibid.* **17:** 5: 6 (May '43). V. Well should be located essentially upstream from possible source of poln., provided that all conditions influencing ground-water movement remain unchanged. Heavily pumped, comparatively shallow well, however, may be so placed as to deflect normal pollutional movement or occasionally reverse it during pumpage. Good practice to locate wells suitable distance from poln. regardless of direction. Increasing pop. and decreasing area restrict choice of site and compel greater reliance on adequate well constr. in lieu of suitable location. In some areas only

TABLE 1

Minimum Safe Distances Between Wells and Sources of Pollution

Source of Pollution	Soil, Deposit or Formation	Minimum Distance From Well (ft.)
Cast-iron sewer with lead calked joints for foundation and similar drains not connected to a sewage disposal system	Clay or similar	10
	Fine sand or sandstone	20 to 40
	Coarse sand to fine gravel	40 to 80
	Coarse gravel—fissured, cracked or broken rock formation.	Adequate distance generally impractical
Clay pipe sewer, grease trap, basement drainage sump, sewer connected foundation and similar drains, steel or concrete septic tanks of best construction	Clay or similar	20
	Fine sand or sandstone	40 to 80
	Coarse sand to fine gravel	80 to 160
	Coarse gravel—fissured, cracked or broken rock formation.	Adequate distance generally impractical
Cesspool, leaching pool, disposal bed, steel or concrete septic tank of questionable construction and comparable surface sources	Clay or similar	Pools will not function
	Fine sand or sandstone	60 to 100
	Coarse sand to fine gravel	120 to 200
	Coarse gravel—fissured, cracked or broken rock formation.	Adequate distance generally impractical

NOTE: Maintenance of the indicated distances enhances the probability of safety of a water supply but does not insure it. Maximum safety is obtained through adequate construction of the well augmented by maintenance of all possible supplementary safeguards.

ground-water supply in relatively thin mantle overlying impermeable formations. In such cases proper location with ref. to poln. only protection available. Aside from sanitation aspect of well location, practical to consider: (1) maint., possible remedial constr., reconstr. or deepening; (2) installation and maint. of pumping equip.; (3) interference with constr. work, structures or usability of premises; (4) interference with proper development of adjoining premises. In recent years, new devices, materials and procedures greatly facilitate locating well in full accord with requirements, without developing impractical conditions. Outstanding example, pitless, frost-proof pumping equip. installation unit enabling thorough san. installation of reciprocating pump in well anywhere on half acre lot, affording unlimited choice of sites accessible and suitable with ref. to poln. Well seals with well vents properly extended facilitate pitless, san. and frost-proof installation of suction, ejector, submersible and air-lift pumps readily accessible for inspection and maintenance. Practical to install such equip. in wells 15′ to 20′ from structure served, insuring fair choice of locations not interfering with constr. on, or usability of, premises served.—*Ralph E. Noble.*

Sterilization of New Wells. LEWIS E. HARRIS. Neb. Munic. Rev. **216:** 19 (July, '42). One of most important duties in relation to newly drilled well is sterilization of well and equip. before connection with storage or distr. systems. Little gained in sterilizing before drilling complete, casing in place and permanent pump equip. installed. Seldom, if ever, water from new well, even after several hr. pumping will pass U.S.P.H.S. or state health dept. stds. Water will show excessive total bacteria, excess of "fermentative types" and, occasionally, *Esch. coli* introduced during constr. and not present in actual supply. Usually impossible to det. actual amt. of water contained or rate of flow exchange in well proper, thus rendering calcn. of dosage impossible. Ordinary bleaching powder (calcium hypochlorite), "HTH" or "Perchloron" most satisfactory sterilizing agents. As nonpoisonous, use excess to accomplish purpose; 1 to 2 tablespoonfuls of former, 1½ to 1 of latter for each well. Mix powder with ¾ cup water to form slurry. Pour and rinse latter into bucket of water and stir with stick several min. Some powder remains undissolved. Pour direct into casing. Ineffective to pour into pump piping as diffusion insufficient to sterilize casing. Soln. corrosive and might affect intricate or closely machined parts but non-corrosive when distributed throughout well. Let stand 12 to 24 hr., then pump several hr., or for 1 or 2 hr. at 2 or 3 intervals. May be necessary to repeat treatment in 10 days. Important that effluent be chlorine-free by taste, smell or ortho-tolidine test before collecting bact. sample to assure accurate bact. examn. Initial sterilization of well does not preclude further chance for contamn. Therefore frequent and regular checks of bact. qual. necessary.—*Ralph E. Noble.*

Wisconsin O.K.'s Used Pipe, but It Must Be Sterilized. ANON. The Driller **16:** 10: 10 (Oct. '42). As war emergency measure, Wis. Bd. of Health approved using properly sterilized reclaimed pipe for well casing. Must be inspected, approved and officially stamped by authorized bd. representative. Approval depends upon conformance to following requirements: (1) wt. at least 90% that of new pipe of same diam.; (2) free from defects including pits, dents and bends; (3) thread on pipe and couplings clean and sharp, to fit and make up properly; and (4) sterilized. Sterilization must be done in presence of state inspector and according to following procedure: Sterilizing agent prepd. by mixing 1 lb. of chlorinated lime of 25% available Cl_2 (or equal) with 50 gal. of clean water. Vol. of this soln. equal to ¼ of pipe capac. put into pipe plugged at one end (wood plug permitted). Upon plugging other end, pipe laid level and rotated at least one full turn every 3 min. for 15 min. Soln. then discharged to waste. After pipe sterilized and officially stamped, shall be painted with lead oxide or aluminum paint.—*Ralph E. Noble.*

Wire Rope Maintenance and Care. ANON. The Driller **16:** 1: 7 (Jan. '42). Material shortages compel drillers to get utmost possible use from all equip. Wire rope in cable-tool drilling transmits power from engine to drilling bit via band wheel, submitted to most severe abuses. When installing new line on drum, sometimes slack loops pull into kinks. Jerking rope around sharp edges of posts, sills or girts may form "dog-legs" causing excessive wear on top side of dog-leg when working up and down in hole. Too steady, pulling tension, under sill or around too small sheave set in rig floor, may cause sharp spiral or curl. Improper and insufficient seizings of rope pre-

paratory to cutting or socketing and improper methods of mandrel socketing frequently develop tight and loose strands, resulting in uneven strand wear and single-strand snapping during operation. New line should be "broken in" by running tools in and out of hole a few times to seat strands on center properly to insure even load distr. to all strands in actual drilling operation. Such line will outperform one not thus broken in. Pinching groove in crown sheave worn small will cause wire fatigue-breaks. Uneven winding on drum causes most dog-legs. Excessive "side-swiping" from wrap of rope as it goes on drum, sliding off previous wrap and resulting in "straight-line" fatigue-breaks along rope surface. Only one correct motion of tools for any one hole condition or depth to conserve wire line designed to give certain "reach" or have certain resiliency and elasticity to give tools necessary power. Over-reaching safe elastic stretch and running too loosely or too tightly cause unsynchronized motions of tools and wire line and early line failure. Jarring tools loose in cavernous holes overstress rope. Premature failure may occur from: (1) excessive wear on one side of rope in crooked hole; (2) excessive abrasion by sharp sands or hard shale; (3) strong briny or corrosive fluids and gases attacking steel, to cause wickering or break-up from corrosion fatigue; (4) prolonged drilling in hard or cave formations results in concg. peak stresses too long in localized sec. Sometimes reflected by "pulling out" of the lay, suggesting need for larger or stronger rope. No more adverse influence on wire line than insufficient lubrication. Continuous use in water, briny or corrosive fluids tend to cut consistency of lubricant and wash it from strands and core. Frequent lubrication allows wires free movement, keeping stresses even during drilling and winding. When corrosive conditions severe, drawn galvanized wire rope, heavily lubricated, definitely resists corrosion.—*Ralph E. Noble.*

Final Report on Survey of Type of Line Used. ANON. The Driller **16:** 2: 10 (Feb. '42). Report summarizes answers to questionnaires sent to 7000 readers, re type of line used in well drilling. Wire drilling cable first introduced in '16. In '32, 62% of drillers used wire, 62.8% manila (many using both). In '40, 67% used wire, 24%, manila and 9% both. In Ariz., La., N.M. and Wyo., drillers use only wire drilling cable while those in Mass., Nev., R.I., Utah, Vt. and W.Va. u manila only. For sand drilling in same y... 91% used wire only, 8.5%, manila and 0.5% both.—*Ralph E. Noble.*

Diary on a Deep Well Drilling Job. CARLTON M. ROBERTS. Eng. News-Rec. **129:** 928 (Dec. 31, '42). Details given of difficulties re priorities, obtaining necessary materials and actual constr. of new well at Asbury Park, N.J. Using 22" roller-type rock bit, hole drilled to depth of 40' and 20" pipe installed and cemented in place. Drilling then continued with 17.25" roller bit, but at 900' huge void encountered and cave-in developed under derrick footing. After filling cave-in with gravel, straw and concrete, 16" pipe placed and cemented to depth of 160' below surface and drilling continued until 11.75" casing could be set to depth of 1072' and grouted. Final operations were cutting of plug in bottom of casing, under-reaming and installation of 80-slot "Everdur" screen, 35' long. Air pressure and surge block used to break down clay wall outside gravel pack. Well equipped with deep-well turbine pump and 30-hp. motor; 24-hr. test showed yield of approx. 800 gpm., 50 gpm. in excess of guarantee. Damage of elec.-driven air compressor serving other wells by elec. storm and subsequent failure of antiquated steam-driven compressor pressed into service necessitated installation of addnl. deep-well turbine pump in another well. When airline removed from well, annular space between it and 10" casing found to be practically filled with Fe deposited from water. New pump in operation 2 mo. and operating costs show reduction of approx. 60%.—*R. E. Thompson.*

Coliform Organisms Found in Private Wells. E. H. GARRARD. Can. Pub. Health J. **34:** 87 (Feb. '43). Of 174 L.B. presumptive pos tubes from 1400 samples derived with few exceptions from private wells in Ont., 4 failed to produce gas in B.G.B. Of these, 2 showed no growth on E.M.B. agar and remainder little, atypical growth. 126 which produced gas in B.G.B. gave good, but not necessarily typical growth on E.M.B. agar. Sub-cultures from pos. B.G.B. tubes yielded 47 *Esch. coli*, 47 *Aer. aerogenes* and 32 intermediates. 42 *Esch. coli* and 1 *Aer. aerogenes* cultures fermented L.B. with gas formation at 44°C. As many of samples yielding *Aer. aerogenes* and intermediate types were from

sources close to possible intestinal poln., suggested that until such organisms definitely proved to be of soil or grain origin they should be regarded as indicative of fecal poln. 13 refs. —*R. E. Thompson.*

Methods for Determining Permeability of Water-Bearing Materials, With Special Reference to Discharging-Well Methods. L. K. WENZEL. U.S. Geol. Survey, Water Supply Paper 887 ('42). Permeability of water-bearing (w-b.) material and capac. to transmit water under pressure detd. by lab. or field tests. In lab., detd. indirectly by anal. of size, shape and arrangement of grains comprising material or, directly, by observing rate of water percolation through samples. In field, detd. by tests of ground-water (g-w.) veloc. or by discharging-well methods, i.e., observing fluctuation of water table or piezometric surface in vicinity of discharging wells. Many specific variations of these methods devised to improve applicability. Thus, several formulas available for computing permeability from mech. anals. of sample materials and many different types of app. used for measuring percolation. Similarly dye, salt, other substances used to det. natural rate of g-w. movement. Several formulas developed for computing permeability from drawdown or recovery of water level near discharging wells. Report outlines gen. methods for detg. permeability and includes some of more widely used variations of each. Includes bibliography of literature on permeability and laminar flow and list of U.S. organizations making permeability tests. 4 pumping tests to det. permeability of w-b. materials made in Neb. in connection with state g-w. resources investigation by U.S. Geol. Survey, in co-op. with Univ. of Neb. Conservation and Survey Div. Three tests made in Platte R. valley near Grand Is., Kearney and Gothenberg; fourth in North Platte valley near Scottsbluff. Water-level fluctuations in many observation wells gave much data on behavior in vicinity of discharging wells. U.S. Geol. Survey, in co-op. with Kan. Geol. Survey, made similar pumping test in Ark. R. valley near Wichita, in '37. Permeability of w-b. materials at locations of 5 tests computed by several discharging-wells formulas outlined. Agreement within 5% on any single test. Included are description of pumping tests, permeability computations and records of water-level drawdowns in Neb. test areas.—*Ralph E. Noble.*

Development of Ground Water Supply. J. W. SIMARD. Eng. Jour. (Can.) **25:** 669 (Dec. '42). To obtain large supplies of water from ground, important to est. capac. of water-bearing formations. Some ground waters not potable. Many methods of measuring veloc. of ground water flow. Modern well constructed in unconsolidated material consists of 3 main parts: outer casing, inner casing and screen. 2 methods of drilling most frequently used for water wells are rotary and cable-tool. Object of development of well to increase filtering area through which water penetrates into well. During development, yield of well increases at same pumping level. In some cases, yields of from 10 to 20 times original output secured. Choice of pump must be with made care. Can now obtain pump to set in 12″ casing to deliver more than 1000 gpm. at 80% eff. To avoid trouble and obtain quick practical results advisable to give same party whole water production job. Water guarantee cannot be given in rock well. Difficult to locate water bearing fissure and no well can be expanded against rock walls (*cf.* Jour. A.W.W.A. **34:** 691 ('42)). Many important water-bearing strata tapped to feed large localities, such as Long Island, Houston, Memphis and Salt Lake City. If wells too close they will interfere but, for reasons of economy, one may be forced to locate wells within cone of interference. By taking adequate measures possible to restore important water strata previously overpumped.—*H. E. Babbitt.*

Artesian Waters and Their Sanitary Control. V. G. POMERANTSEV & M. G. PYSHKIN. Hig. i Sanit. (U.S.S.R.) *No.* 7–8: 19 ('40). Expts. carried out in Orekhovo-Zuevo. Contamn. of artesian waters could take place as result of combining with piped water for tech. purposes. Daily san. control absolutely necessary. In conditions of Orekhovo-Zuevo, most important part of san. tech. control is daily detn. of pH, of chlorides and of hardness which is due to carbonates. Complete san.-chem. anal. of artesian, ground and river waters should be carried out 4 times per yr. Parallel bact. control method should be carried out.—*C.A.*

Criteria for Recognition of Sea Water in Ground Waters. ROGER REVELLE. Trans. Am. Geophys. Union ('41) p. 593. Modifications in compn. of sea water on passing through soil due to base-exchange between water and

soil minerals, sulfate reduction and substitution of bicarbonate or other weak acid radicals, and soln. of soil salts or pptn. of some constituents of water. Concluded that most reliable index of sea water intrusion is increase in Cl/HCO_3 ratio, especially where contamn. with saline wastes, evapn. and pptn. unlikely. —*C.A.*

Western Ground Waters and Food Production. JOHN A. BIRD. U.S. Dept. of Agric., *Misc. Pub.* 504 (Dec. '42). Author stresses importance of ground-water supply to agric. in Western states, particularly where annual rainfall low, droughts real or potential hazards and irrigation economic necessity. Nature and mechanics of ground water explained. Knowledge and observance of Western ground-water law essential to planning and use of water. Courts generally consider 2 classes of ground water—underground streams and percolating waters. Underground streams subject to riparian or appropriation doctrines according to law of state involved. Percolating waters those in ground other than those flowing in definite subterranean streams. English rule of *absolute ownership*, American rule of *reasonable use* and newer *appropriation* doctrine explained. Latter particularly advanced in N.M. Any permanent stability of people on land requires practical, long-range balance between land and water. Usually obtained only through thoughtful planning for wise use of both land and water. Effects of unplanned developments in relation to ground-water use include poor distr., waste and inefficient use., inefficient equip. and design and lack of land-water co-ordination. In comparison, projects cited where planning pays dividends. Author outlines planning process in Republican R. basin under Water Facilities Program for 125,000-acre irrigation development. Recommendations as to water and land use detailed.—*Ralph E. Noble.*

Report on Water in Los Angeles Basin. ANON. The Driller **16:** 11: 10 (Nov. '42). U.S. Geol. Survey concerned over possible deterioration of ground water supply in Los Angeles Basin of Calif. During recent years, total daily draft for all uses from wells in Basin avgd. about ¾ bil. gal. With increasing draft, salty water appeared in some Basin wells and along coastal edge. In co-op. with several local agencies, U.S.G.S. investigating to det: (1) whether ground water supply qual. deteriorating because of incursion of ocean water, oil well brine, or indus. wastes; (2) deg. of continuation at present rates of withdrawal; and (3) deg. preventive or remedial measures feasible. Duplicate copies of unpublished report on, "Index of Factual Data From Water Wells on a Part of the Coastal Plain in Los Angeles and Orange Counties," on deposit for consultation.—*Ralph E. Noble.*

Summary and Review of Ground Water Levels in Louisiana During 1942. J. C. MAHER. Louisiana Conservationist **1:** 4: 1 (Mar. '43). Periodic observations, begun in '38, of levels and pressures in selected wells embraced 88 wells in 15 parishes during '42. Water stage recorders installed in 11 wells. Considerable part of program connected with war establishments. Bastrop well level was 1.9′ higher in Dec. '42 than in Dec. '41 due to small decrease in consumption by paper mill who developed supplemental surface supply. In 3 central La. parishes where consumption small, levels remained const. Levels at Alexandria declined over 19′ during past yr.; new field being drilled for alleviation. Rice irrigation wells in S.W. La. declined 2′ at Welsh, despite excessive summer rainfall. In vicinity of Lake Charles decline expected due to industrial expansion. Pressures of artesian wells in S.E. La. compare favorably with previous year. Holden well, originally 61 psi. in '39, highest record in state, now 55 psi. In strawberry belt, artesian wells, used for irrigation, shut down during off seasons to conserve pressures. St. Tammany parish, with 1147 wells totaling above 35 mgd., recorded loss as high as 1 psi. Most concentrated withdrawal in East Baton Rouge Parish, approximating 53 mgd. in summer. About 85% of industrial pumpage from 400′ and 600′ sands supply cooling water; level declined 150′ to 200′ since '14, but rose 0.44′ to 7.71′ during '42 due to high summer rainfall. Artesian pressures in 1000′ to 2550′ wells declined 9 to 7 psi. and required turbine pump installations. At New Orleans, only fresh water sand is at 700′ and contains brackish water in part of area; lowering of levels may permit encroachment.—*A. A. Hirsch.*

Regional Water-Bearing Strata—The Boulonnais. J. SALMON & A. SALMON. Ann. Hyg. Publ. (Fr.) **18:** 53 ('40). Discusses ground water resources and geology of dists. of Lower and Upper Boulonnais. In Lower Boulonnais water from springs or wells in Portland stone stratum requires disinfection

before use as supply. Waters from deep wells usually of good qual., but may have high content of mineral salts. Ground water of this region not sufficiently plentiful to be drawn on for supplies of any considerable size. In Upper Boulonnais water from wells in cretaceous rock usually contamd. by infiltration. Springs rising from considerable depth may be suitable for supply, but supervision necessary after rain. Springs from shallow strata generally supply water of poor qual. Boulogne and many other towns use both deep and shallow wells to obtain ground water which is disinfected, yielding supply of good qual. Other places draw supplies from below greensand; these supplies require no treatment. Tables of anals. of water from some wells of dist. given. Problem of water supply could be solved for whole dist. by collective supply drawn from cretaceous rocks.—*W.P.R.*

DAM CONSTRUCTION AND MAINTENANCE

Design of Hydraulic Structures Resting on Clayey Soils. A. N. KHOSLA. Wtr. & Wtr. Eng. (Br.) **44:** 54 (Mar. '42). (*Extract from Ann. Rpt. '39–'40 of Central Board of Irrigation, India.*) Suleimanki weir of Sutlej Valley project founded on sand underlain with layer of clay about 10′ deep. Below again sand. Only one pile line under floor, located directly under crest at position of gates. Pile line bedded into clay but does not puncture it. This an illustration of correct design. In all works founded on permeable subsoils, pile line at downstream end of impervious floor considered essential to secure work against undermining. Depth of pile line detd. from two considerations: (1) exit gradient should not exceed safe limit, and (2) floor thickness should not be excessive. From study of many major works found that absolute max. uplift pressures do not exceed 75 to 82% of theoretical. No data available for depth of scour in clay soils. C.B.I. Pub. No. 12 gives this depth as: $R = 0.9\, q^{\frac{1}{2}} \div f$, where R = depth of scour, q = dischg. per ft. run., and f = Lacey's silt factor. Recent study of scour at Rupar weir has shown that f may be ignored. To det. depth of scour at any particular locality, value of R so obtained should be multiplied by relevant factor to allow for local concn. and obliquity of flow, *viz.*, straight flow, 1.25 R; moderate bend, 1.50 R; severe bend, 1.75 R; right-angle bend, 2.0 R. Geol. investigations by boring must be done in case of all hydraulic structures, more particularly those founded on clayey soils or on sands with clay substrata. Where work founded on sand overlying clay substratum, downstream pile line must never bed into clay substratum. Boxing in of foundations on flanks by means of sheet piles or deep walls will be desirable in all cases. Floor slabs downstream of crest or gate line should be designed for full uplift pressures in case of major works. For minor works, on predominantly clayey but homogeneous soils, floor slabs may be designed for ¾ of theoretical uplift pressures. For those founded on impervious clays, with cut-off wall under crest, pressures under downstream floor will be negligible and floor thickness will be mainly matter of judgment, but should be adequate to withstand dynamic action of scour. Exit gradient for clayey soils may be taken as 1 in 3 to 1 in 5 depending on proportioning of sand and clay. Depth of scour in clayey soils will presumably be less than in sands for same concn. of dischg. Scour depth appears to be independent of mean diam. of bed material but further studies must be carried out before final recommendation can be made.—*H. E. Babbitt*

Permeability of Mud Mountain Dam Core Material. ALLEN S. CARY, BOYD H. WALTER & HOWARD T. HARSTAD. Proc. A.S.C.E. **68:** 1089 (Sept. '42). Moisture content of material when compacted had much greater influence on permeability than did density of material within range of densities at which it would be compacted during constr. Wide range of void sizes may be imparted to soil at will, with no variation in density being necessary. So pronounced were effects of slight moisture differences on permeability of material that moisture control during constr. became of paramount importance, not so much for usual density control but for control of permeability of core material. Optimum water content is content at which max. density is produced in soil by specific amt. of compaction. Void ratio is ratio of vol. of intergranular space to vol. of solid particles in given soil mass without regard to proportions of liquid, air or gas which may occupy the space. Void ratio expressed as number does not define nature of voids. Numerically, void ratio is measure only of total vol. of

voids. Void ratio may be reduced progressively by consolidating sample without appreciably disturbing particle and void distr. These appear to be controlled by exercising control of water content at which sample is compacted into permeameter. Numerical void ratio appears to govern permeability at upper and lower limits of water content at which materials tested, but at relatively narrow range of water contents near optimum enormous changes of permeability take place with no change in void ratio necessary. In detg. permeability of certain pervious foundation materials sometimes impossible to obtain undisturbed samples or to test material in place, in which case common practice to det. permeability of remolded samples over range of void ratios. If series of tests is run on samples of material compacted at various water contents, however, results will indicate degree of confidence that may be placed in predictions of seepage through foundation materials.—*H. E. Babbitt.*

Aeration of Spillways. G. H. HICKOX. Proc. A.S.C.E. **68:** 1777 (Dec. '42). Direct result of insufficient aeration of overfall weirs reduction of pressure beneath nappe due to removal of air by overfalling jet. Reduction of pressure in turn causes several undesirable effects. First, increase of pressure difference on weir itself. Reduction of pressure on downstream side may increase resultant load on structure to point of failure. Second effect, change in appearance of nappe which is depressed below normal position. In large spillways upper surface becomes ridged in direction of flow and begins to entrain air instead of being smooth as for normal flow. Nappe may break, allowing air to pass through it. As soon as this occurs, nappe springs back to normal position and process of air exhaustion and breaking of nappe repeated. Third, increase in pressure difference causing flow over weir and corresponding increase in discharge coef. Information necessary (1) to prevent excessive loads on spillway gates; (2) to insure reliability of model tests; and (3) to provide criterion for necessary aeration of measuring weirs. Found that relationship between pressure reduction, air required and head over top of gate could be represented by plotting

$$\alpha = \frac{(q_a)^{0.5}}{g^{0.25}p^{0.25}H_o} \quad \text{against} \quad \beta = \frac{(q_a)^{0.5}}{g^{0.25}p^{1.25}}$$

in which q_a = rate of air supply per ft. length of crest, $\frac{Q_a}{B}$; p = reduction of pressure beneath nappe, in ft. of water; g = acceleration of gravity; H_o = head over top of gate corresponding to pressure reduction p; Q_a = rate of air supply in cfs. at atm. pressure; B = length of weir crest, ft. Quant. of air required per ft. length for weir operating under specified conditions of gate opening, head and pressure reduction beneath nappe is $q_a = \frac{(CH_o)^{3.64}g^{0.5}}{p^{1.14}}$ in which C is const. for each value of dimensionless ratio $\frac{y\sqrt{H_u}}{H_o^{1.5}}$; y is height of opening below gate, ft.; H_u, head on center of opening below gate, corresponding to pressure reduction p, ft. If discharge coef. of weir assumed const., ratio of increase in discharge (due to reduction of pressure beneath nappe) may be written as $\left(\frac{H'}{H}\right)^{1.5} - 1$ in which H is head on weir, ft., and H' is head over top of gate for full aeration, ft. *Discussion. Ibid.* **69:** 422 (Mar. '43). JOE W. JOHNSON: Air withdrawn from underside of nappe by falling sheet acting as friction pump. Withdrawn air replaced from 2 sources: (1) air that flows through vents to space under nappe; (2) air which, upon being drawn into downstream pool by both sides of falling sheet, strikes channel bottom and circulates back and upward to space under nappe. Observations of writer on 1′ weir indicated that quant. of air withdrawn proportional to veloc. of falling sheet or, within certain limits, to discharge. When deflector placed to prevent air from entering into space under nappe by any method except through vents, quant. of air withdrawn given by eq.:

$$q_a = \frac{(CH_o)^{3.64}g^{0.5}}{p^{1.14}}$$

based on all available lab. and field data. For certain head effect of preventing free access of air to underside of nappe gives discharge greater than that obtained by complete aeration. Max. increase in discharge of 23% resulted with "adhering" nappe; "wetted underneath" and "depressed" conditions gave increases of 18% and 6%, resp.—*H. E. Babbitt.*

Some Types of Modern Sluice Gates. P. L. BOUCHER. Civ. Eng. (Br.) **37:** 72 (Apr. '42). Principal factors affecting gate design are span, depth and head of water. Simplest sluice gate of sliding type, with door and

frame of mild steel or c-i., with or without gunmetal faces. When these impracticable, roller gates employed and deadweight of gates may be counterbalanced. "Fixed" rollers used for gates of medium size and "free" rollers for largest and heavily loaded gates. Fixed rollers roll on axles rigidly attached to gate structure; free rollers suspended in trains and run on machined paths on portal frame. Roller gates sealed at sides by independent elements, of which various forms include: machined facing strips on gate and portal frame; tubular seals comprising accurately machined tubes suspended at each side of gate and held by water pressure; and flexible seals of Balta or rubber constr. attached to gate edges and extended over suitable faces on portal frame, against which seals held by water pressure. No. of other types of gates among which may be mentioned hinged outfall sluices, tilting gates, radial gates, combined tilt-radial gates, and drum gates. [Each type illustrated.] Type of outfall sluice with counterbalanced door very sensitive. Will function with head of only 1″ or 2″ on culvert side. Greater sensitivity can be obtained by using large-diam. rollers. Gates will dischg. with only fraction of inch on culvert side. Drum gates suitable for spillway control of large dams. Small sliding gates usually operated by cross-bar or handwheel which rotates a nut, housed in casing on top member of frame, engaging a screw attached to door. Large roller sluice gates can be operated by wire ropes which coil on drums that are rotated through suitably geared headstocks. Tilting and radial sluice gates can readily be arranged to work automatically without external power. Controlling factor variation of water level in forebay.—*H. E. Babbitt.*

Fish Passes. *Report of Research Com. of Inst. of Civ. Engrs.* ANON. Wtr. & Wtr. Eng. (Br.) **45:** 25 (July '42). Modern fish passes may be divided into 4 types: (1) pool; (2) flight of stepped pools, or fish ladder; (3) steep channel; and (4) lift or elevator. Fish may show definite distaste for one type. Hence design is not merely eng. and hydraulic. Design of entrance of pass is of importance so fish may readily find and enter it. Problem of energy dissipation enters. In pool type there must be no appreciable veloc. of approach at opening of lower pool. In channel pass, problem is to dissipate energy to secure even flow at sufficiently low veloc. This type of pass represented by several successful examples in Belgium. Fish-lock or fish-lift not used in Great Britain.—*H. E. Babbitt.*

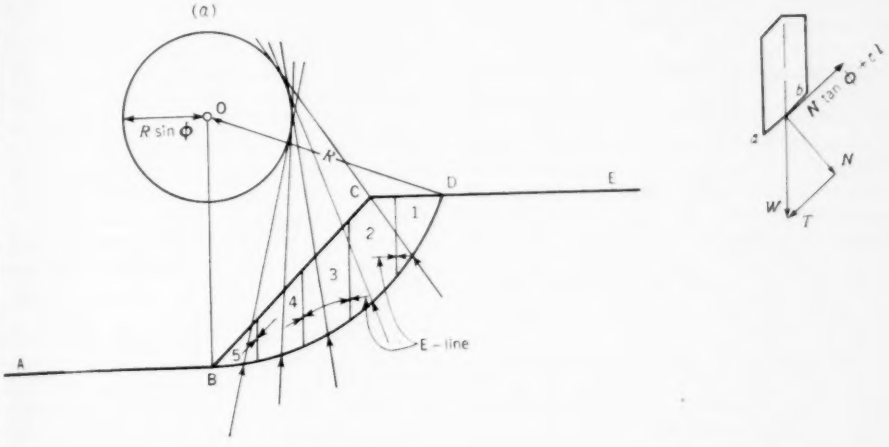
Nomograph for Computing Elevations of Stilling Basin Aprons. CLARENCE FREEMAN. Civ. Eng. **12:** 157 (Mar. '42). Trial-and-error methods normally used to det. theoretical apron elevations for spillway or conduit stilling basins in which dissipation of energy obtained by hydraulic jump. This cumbersome procedure may be elimd. by use of simple nomographs suitable for prelim. or approx. design. Constr. described. Nomograph applicable to any design conditions where upstream el. of energy gradient, tailwater el. and unit discharge known.—*H. E. Babbitt.*

Historic Accidents and Disasters. ANON. The Engr. (Br.) **174:** 432, 452 (Nov. 27, Dec. 4, 142). *The Bradfield Dam, Sheffield:* When dam failed Mar. 11, 1864, it released flood which drowned 238 people and destroyed property estd. at £200,000 in value. Dam earthen embankment with puddle core. At highest point, dam rose 95′ above original valley surface; 12′ wide at top and 500′ wide at base, with slopes 2½ : 1. Puddle core tapered from width of 4′ at top to 16′ at foot. Dam contained 400,000 cu.yd. of earth and designed to impound 114 mil.cu.ft. of water. Trial holes sunk at intended site showed that there had been disturbance of strata. Accordingly, another site higher up in valley selected. During excavation, trouble caused by inflow of water from sides. Fact that percolation of water through strata increased by removal of overburden caused no apparent misgiving. Puddle trench had to be carried down to depth of 60′ below ground surface instead of anticipated 10′. Two 18″ c-i. pipes beneath embankment subjected internally to full hydrostatic pressure of impounded water when valves closed. Thus, pipes called upon to bear force acting to pull them apart at joints. Sockets, therefore, cast with conical bores, with thought that lead would not be squeezed out. No collars cast externally on pipes. On Mar. 11, 1864, water within 3″ of top of spillway. Weather preceding was wet and windy so that all low country had been inundated. On fatal day, gale blowing and wind and waves playing against upstream face loosened material, with result that puddle wall tilted forward causing crack in downstream face. Before shot could be fired to provide opening to facilitate escape of water, embank-

ment burst. *The Bouzey Dam:* Design of dams of all forms subject in which guidance of math. must be tempered by experience. Even middle-third principle based on arbitrary assumption, validity of which never proved. Bouzey Dam across River Aviere, near Epinal, France, provides example of dam in which middle-third principle was flouted. Dam masonry structure, 1732′ long in straight line across valley. It formed reservoir holding 7 mil. tons of water. Dam designed to be 66′ high above foundation on sandstone; 13′ wide at top, with this width maintd. for depth of 14′; whereafter downstream face turned with large radius to meet lower inclined portion which, at foundation level, had width of about 37′. Erection of dam begun in 1878. During constr. height of dam raised 6½′. On Mar. 14, 1884, 450′ portion of dam slipped on its base and arched downstream, max. deflection amounting to about 15″. Flow from springs below dam increased, at same time, to 1700 gpm. Nothing done for 18 mo. and water level allowed to rise 7″ or 8″ higher. In autumn of 1885, reservoir drained and dam inspected and some repairs made. In Nov. 1889, within 2 mo. of completion of repairs, water allowed to rise even higher than at time when slip occurred in 1884. On Apr. 27, 1895, whole upper portion over length of nearly 600′ swept away. Flood destroyed or damaged six villages, no. of bridges, part of railway and drowned over 100 people and thousands of cattle. Engrs. proved dam exposed to tensile stresses near upstream face. Three factors—designer's neglect of middle-third principle, inferior qual. of mortar and inferior qual. of stone—in conjunction, sufficient to explain eventful history of Bouzey Dam. Infiltration of water beneath Bouzey Dam must be accepted as true. Alternative contemporary theory was that water pressure was admitted into horizontal crack in upstream face at some level above base. Current opinion found addnl. factor in application of uplifting pressure applied to base of dam. Sixth factor may be conceived to be analogous to phenomenon of "creep" in metals. Expansion of lime mortar carelessly prepd. may continue progressively for months after mortar laid. Disastrous failure attributed to this cause provided by bursting of Habra Dam in Algeria, in 1881, some 8 yr. after being brought into use. Bouzey Dam failed because of bad design allied with inferior materials and defective workmanship.—*H. E. Babbitt.*

The Analysis of the Failure of an Earth Dam During Construction. LEONARD FRANK COOLING & HUGH QUINTIN GOLDER. J. Inst. Civ. Engrs. (Br.) *No.* 1: 38 (Nov. '42). Study of failure of earth banks begun simultaneously in three countries before last war. One result was method of calcg. stability of earth bank usually known as Swedish method, based on fact that when bank of cohesive earth fails it does so along approx. cylindrical surface rotating about axis of cylinder. Among most important methods of stability anal. advanced are ϕ-circle and log spiral method. Cohesive soil is soil in which shear strength wholly due to cohesion between particles and therefore same in all directions, being independent of normal pressure on plane of shear. In practical case of anal. of failure position of arc of rupture can be observed on site. In design, however, position of arc of rupture not known and must be found by trial factor of safety being calcd. for no. of arcs until min. value found. Factor of safety against failure along arc is: $F = \frac{sLR}{Wd}$, in which W = weight of earth in sliding segment; d = lever arm of W about center of arc; s = shear strength of soil along arc; L = length of arc; R = radius of arc. In frictional soil, shear strength proportional to normal pressure on surface of shear. In Swedish method, section of earth divided into vertical slices and assumption made concerning position and direction of forces acting between slices. Problem then capable of solution by graphical means. Referring to accompanying diagram, let bank section BCDB be divided into vertical slices, as shown. Forces on each slice are weight W, reaction Q across arc at base (inclined at ϕ to normal, where ϕ denotes angle internal friction of soil and reaction Q is made up of normal reaction N and tangential force $N \tan \phi$) cohesion along arc, and forces E_1 and E_2 exerted on slice by neighboring slices. For any slice disturbing moment is $Wd = TR$, where T denotes resolved part of weight tangential to arc ab. Factor of safety of bank against slip is $F = \frac{cL + \tan \phi \Sigma N}{\Sigma I}$. Procedure must be repeated until worst circle found. Possibility of slip below toe must not be overlooked. Swedish method of slices can be applied to anal. of bank in which different materials occur, simply by taking different values for shear strength over parts of arc of rupture

lying in different materials. In July '37, during period of fine weather, failure occurred during constr. of earth bank to form storage reservoir at Chingford, Essex. Bank had reached height of approx. 26′. Section of outer sloped moved out over length of about 300′. Toe moved out 14′. No. of cores of soil taken from different parts of bank and foundation soil. Weight of bank material detd. by weighing cores. Shear strength of yellow clay, select fill and puddle clay detd. by tests in lab. Water content detns. carried out on all samples. Trace of failure surface showed that shape of slipped mass departed from normal cylindrical form. Reason was it would be expected that surface of failure would tend to pass through yellow clay and puddled core rather than through stronger bank material. Examn. of shape of probable surface of failure indicated that 2 circular arcs tangential at point of contact, one $R = 39'$ and other $R = 288'$ gave close agreement. Method of anal. capable of extension to more complicated surface of rupture. Instructive to compare observed difference between shear strength of clay at time of slip and at time bank stripped. At time of slip, most of bank material in position about 37 days and mean shear strength of clay 2.0 psi. Later samples taken after 8 mo. showed mean shear strength under 26′ of bank to be 5.2 psi. Difference between observed increase of 3.2 psi. and calcd. increase of 4.4 psi. attributed to uncertainty of extent of drainage layers and to variability of material and its thickness. Swedish circular arc method capable of comparatively simple extension to complex surfaces of rupture. Method particularly useful in anal. of earth-fill reservoir dams with puddled clay cores.—*H. E. Babbitt.*



Developing the Neversink Watershed. THOMAS L. WELLS. Explosives Engr. **20:** 166 (June '42). N.Y. City Bd. of Water Supply made $3,406,895 contract for stream control and caisson sinking at proposed Neversink Dam and Reservoir site in Catskills. Present phase comprises: (1) Constr. of 2000′ rolled embankment coffer-dam to be incorporated into main dam structure. (2) Driving 30′ diam. concrete-lined, circular diversion tunnel 1435′ through rock in east abutment, with connecting 45° inclined tunnel. (3) Sinking 2 reinforced concrete caissons to bedrock on center-line of proposed main dam. (4) Excavating cutoff trench on center-line of future dam structure. Neversink Reservoir will draw on 93-sq.mi. watershed of Neversink R. to produce water, 70 mgd., for relay through 6-mi. Neversink-Rondout Tunnel to Rondout Creek Reservoir, thence through 85-mi. main aqueduct. These 2 reservoirs will constitute prin. storage areas in first stage of Del. Water Supply development, together making available 170 mgd. to N.Y. City area. Present development designed to control Neversink R. during constr. of main dam later. Coffer-dam to be included in main dam as part of upstream toe. Diversion tunnel, besides bypassing river around coffer-dam, will be connected

through inclined shaft with spillway channel of main dam discharging overflow to river bed below. Exploratory caissons and cutoff trench aid design of main dam by detg. depth of ledge rock, soil and water conditions along and under center-line of proposed structure. Caissons to be incorporated later into main dam cutoff wall. Diversion tunnel major item. All above constr. features detailed. All pumpage water from constr. area, including diversion tunnel, caissons, deep wells, cutoff trench and other excavations, required settling and chlorination as safeguard to water courses below. Entailed provisions for settling basins and installing large capac. chlorination plant. Permanent san. services part of contractor's responsibility. Modern san. septic tanks and sand bed filtration erected to handle sewage, drainage, other dirty water from constr. area.—*Ralph E. Noble.*

Cofferdamming for Giant Kentucky Dam. JOHN H. D. BLANKE. Internatl. Engr. **82:** 165 (Dec. '42). TVA engrs. laid bare wide bottom of Tenn. R. by constructing 2 huge cofferdams of unique design and excavating inside so another concrete and earth dam can be constructed for navigation, flood control and power generation. Dam 160′ high, 8650′ long; about 1800′ concrete, 6600′ earth enbankment. Its constr. provided 9′ deep navigation channel 184 mi. upstream in which distance river dropped less than 0.3′ per mi. Shoreline of river reservoir about 2000 mi. at reservoir level of 16′ below top of dam gates. Area at top of spillway gates, 256,000 acres. Vol. 6,100,000 acre-ft. at top of gates; controlled vol. above low pool level, 4,570,000 acre-ft. Extensive channel, camp facilities, railroad pier protection, river bottom at dam site, constr. quants., excavation of overburden, aggregate and concrete, uncovering site for dam, and such cofferdam constr., other details as pile-driving rig, cofferdam cells, foundation treatment, unwatering of cofferdam, cell drainage, maint. of pumping, cofferdam flooding, described.—*Ralph E. Noble.*

The Appalachia Project of the TVA. C. H. VIVIAN. Compressed Air Mag. **47:** 6723 (May '42). Project includes greater variety of hydraulic features than any previous TVA undertaking. $20,000,000 job will consist of 150′ concrete dam from which water will flow through 8-mi. conduit, then drop through 2 penstocks to turbogenerators and be returned to Hiwassee R. Appalachia Dam will create lake extending 10 mi. upstream. Surface area at full-pool level only 1150 acres. Total storage capac. 62,500 acre-ft. Storage capac. of Hiwassee, Chatuge and Nottely reservoirs can insure min. supply of 2120 cfs. in abnormally dry yr. and 3000 in normal dry season. From Hiwassee Dam to Appalachia project river flows 22.3 mi., falls 434. L. & N. R.R. tracks along river preclude dam constr. to back water up to tail-water el. Instead, will constr. comparatively low dam just above where R.R. leaves canyon and divert river through conduit to power-plant downstream. Dam will have deck el. of 1288′; normal full-pool el. of reservoir, 1280′. Invert of conduit intake at el. 1212′. Water flow on avg. 0.0362% gradient, dropping 157.7′ between dam and penstocks opening at el. 1054.3′. Max. head at penstocks will be 216.3′. Combined max. static head of 442′ will be reduced to 400′ after deducting friction losses. Excluding penstocks, conduit will be composed of 42,201′ tunnel and 1475.5′ steel pipe. Longest pipe section 906.5′ from dam to upstream portal of tunnel system. Tunnel divided into 6869′, 13,902′, 7702′, 12,772′ and 956′ sections. Circular cross-section 20′, lined with 1′ concrete. Geology, drilling, surge-chamber, mucking and air-compression phases of project detailed.—*Ralph E. Noble.*

A Concrete Dam. CHARLES F. LAPWORTH. Wtr. & Wtr. Eng. (Br.) **45:** 3 (July '42). Concrete dam recently completed in south of England is 45′ max. height, 325′ long at top water level, and impounds 140 mil.gal (Imp.). Dam designed as gravity section with max. foundation pressure of 3.7 tons per sq.ft. Curved in plan with radius of 500′ to upstream face. Overflow is over portion of downstream face of dam into tail-bay which joins original course of stream. Total cost of works about £60,000. Work commenced in Mar. '39, reservoir being brought into commission in Feb. '42.—*H. E. Babbitt.*

Addition to a Concrete Dam. H. B. WARD. Civ. Eng. (Br.) **37:** 138 (July '42). Dam designed as gravity section, of mass concrete with precast concrete blocks for facing on each side. Curved in plan. Before 10′ in height added to dam, anal. of stresses made. On basis that dam was straight, max. tension on upstream face is 28 psi. at ⅓ total depth. Dam being curved, tension will not be realized.

During work, water was drawn from reservoir as usual. Interesting to note that no silt had collected at bottom of dam after years of use of reservoir. Constr. cost of original dam was £20,000 and that of addnl. 10′, £5000.—*H. E. Babbitt.*

The Somerset Dam, Queensland. ANON. Surveyor (Br.) **102:** 41 (Jan. 22, '43). Somerset Dam being built on Stanley R. immediately above confluence with Brisbane R. for water supply and flood mitigation. Dam is gravity structure, 1000′ long, 163′ high above gen. foundation level. Central spillway 250′ long controlled by eight 16′ × 23′ sector gates. Foundation generally sound blue porphoryte. Minor seams or joints treated by low-pressure grouting.—*H. E. Babbitt.*

The Scanlon Dam on the Lois River, British Columbia. ANON. Engineering (Br.) **154:** 441 (Dec. 4, '42). Dam, located on Powell R. about 80 mi. north of Vancouver, variable-radius, concrete-arch type. Max. height from bedrock 205′, total crest length 680′, west wing wall 186.75′ and thrust block 115.28′. Spillway will have 5 "Taintor" gates 20′ wide × 21′ deep, and 1 "Taintor gate" 10′ wide × 9′ deep. Excavation for foundations started in May '40. Work involved 30,000 cu.yd. rock and river-bed excavation and placing of 61,000 cu.yd. concrete. —*H. E. Babbitt.*

The Gebel Aulia Dam. ALEC GEORGE VAUGHAN-LEE. Wtr. & Wtr. Eng. (Br.) **43:** 240, 266 (Aug., Sept. '41). To obtain more summer water in Egypt from White Nile, proposal put forward about 1910 to construct dam at Gebel Aulia, about 26 mi. above Khartoum. Dam probably one of longest impounding dams in world, divided into masonry and embankment section; 5554′ and 10,850′ in length, resp. Sandstone used extensively in embankment sec. All cement required mfrd. in Egypt, structure being first major public work of importance that has been constructed throughout with Egyptian portland cement, mfrd. in accordance with British std. specifications. Solid dam constructed of granite rubble masonry in 3 : 1 cement mortar and faced with granite mosaic. On both faces of solid dam three courses of heavy ashlar provided to form corbels and to provide as wide roadway as possible. Constr. of sluice dam executed on similar lines to solid dam, except that it was pierced for 60 sluice vents, of which 10 were not fitted with gates. The 50 sluice gates are of Stoney, free-roller type, having clear opening 3.0 m. wide by 4.5 m. high. Navigation lock 80 m. long between heel posts, 18 m. wide, and 135 m. over floor. Fish ladder consists of 9 water leaps, each 70 cm. high. Cost of work amtd. to £E1,984,200. (£E1 = £1 0s 6.15d.)—*H. E. Babbitt.*

Dam at Cruz de Piedra, Argentina. CARLOS A. VOLPI. Civ. Eng. (Br.) **37:** 99 (May '42). Urgent need to increase both potable and irrigation water in neighborhood of San Luis. Govt. decided to carry out control works on river Cuchi-Corral by means of dam at Cruz de Piedra. Site conditions are narrow gorge with rocky banks, with alluvial bed 20 m. deep in river to crystalline bedrock in stream bed. Main dam Ambursen type 117 m. long at crest level, with max. height of 36 m. Width of top 2 m. Design of slab and counterforts based on that of Stony Gorge dam, built in '30 by U.S. Bureau of Reclamation. Intake works located on right bank between adjacent counterforts, c-i. penstocks being 0.80 m. in diam. and 22 mm. thick. Flood water spillway, sited remote from main dam, has length of 105 m. and capac. of 920 cu.m. per sec. Works started in May '38 and finished in May '41 with contract value of $2,589,000.—*H. E. Babbitt.*

Corrugated Sheet-Steel Catenary Dam. ANON. Engineering (Br.) **152:** 387 (Nov. 14, '41). Dam, located in Australia, has crest length of 270′, with 24′ greatest depth of water. Structure of interest because of novelty and advantages over more conventional types. Can be constructed rapidly and at low cost. In some respects dam resembles fixed deck type sometimes used in U.S., comprising triangular buttresses with semicylindrical corrugated steel sheets between them, curved away from water flow. Sheets thus in tension and hence use of term "catenary." Buttresses tied together by crest of dam. As no large masses of concrete rest on more or less flat surface, problem of hydraulic uplift not important. Cost of dam likely to be only ⅓ or ¼ that of gravity wall. Life guarantee of steel sheeting 15 yr. Anti-corrosive agent being exptd. on of such character that it improves in water and, by its use, life of steel sheeting may be prolonged to period exceeding that guaranteed by sheeting mfrs.—*H. E. Babbitt.*

War Production Board

Office of War Utilities

Administrative Letter to All Water Utilities—OWU-6—June 23, 1943

MATERIAL FOR MAINTENANCE, REPAIR AND OPERATING SUPPLIES AND FOR CONSTRUCTION OF ESSENTIAL FACILITIES

1. Maintenance, Repair and Operation

The splendid co-operation of the water utilities during the past year in reducing to a minimum the use of material for maintenance, repair and operating supplies has been of great assistance to the war facilities construction program.

Because of the major importance of water supply to the nation's war effort, the Office of War Utilities has provided, both through Utilities Order U–1 and close co-ordination with manufacturers of utility supplies, arrangements to facilitate maintenance of essential plant. It is sound policy for utilities to plan for a long war and to maintain equipment in good operating condition at all times. In order to be assured of receiving necessary repair parts and material when needed, each utility should develop a sound maintenance program so that long range planning by this office for scheduling production and alloting of necessary materials may be put into effect.

As soon as your requirements can be determined, orders should be placed with suppliers using the rating and allotment symbol of U–1 and scheduling the delivery of materials about one month in advance of scheduled repairs.

Promises of shipment against such orders should be obtained from each supplier. If unsatisfactory promises of delivery are received, the Water Division of the Office of War Utilities should be notified immediately in order that appropriate action may be taken.

In case of breakdowns or other emergencies requiring special attention, it is proper, depending on the urgency, to telephone or telegraph the Water Division. To help you, we shall need:

a. A description of the material or equipment required

b. Name and address of the supplier and your order number

c. Approximate dollar value of material or equipment

d. Present preference rating and delivery promised

e. Required delivery date.

It is important that all purchase orders for material for repairs and maintenance placed before March 31, 1943, be re-rated with the preference rating and allotment symbol of Order U–1. It is suggested that you send a letter to each supplier advising him of the re-rating and endorsing on your letter the Certification of Utilities Order U–1.

If you take the initiative in the manner outlined, it will expedite delivery of material required to keep your essential plant facilities in first class condition.

2. Construction of Facilities

Any minor addition or expansion of plant for which net material costs are less than $1500 in the case of underground construction and $500 in the case of other construction is defined by utilities Order U–1 as excluded from "construction." Therefore, under U–1, the materials for such minor jobs may be secured as "operating supplies." "Construction" means any addition to or expansion of property or equipment having a dollar value for material in excess of these limits for minor jobs. Net material costs are determined by subtracting the value of salvage from the actual cost of new material used.

3. Replacements

Utilities Order U–1 permits the replacement of property and equipment *unfit* or *unsafe* for service without limitation on the dollar value of any single job, *except* for the dollar value restriction on total withdrawals of material in the same class in paragraph (f), and provided that the replacing equipment is of the same kind, quality and design as the equipment replaced, and is essentially of the same capacity. On each replacement job, the additional use of material having a dollar value not in excess of the $1500 or $500 limits mentioned above for minor capital additions is permitted under paragraph (h)(1)(iii), provided the job is not an extension of a pipeline to consumer premises. *Replacement* of a pipeline to consumer premises is not an *extension* of a pipeline.

4. Additions

When essential additions or expansions of plant exceed the dollar value limitations of work which may be done under Order U–1, application should be made promptly on Form WPB–2774 [*see* p. 977]. Form WPB–2774 replaces for all utilities all previous forms (such as PD–200, PD–200B, PD–1A and U–1 letter applications) used for applying for approval of construction of facilities.

The supply and demand situation with regard to various types of material and equipment changes as the requirements of the war program vary. Applicants for projects are reminded, however, that availability of manpower and transportation facilities must be taken into consideration as well as availability of materials and equipment. Non-essential projects cannot be approved during this critical war period.

5. Requirements

By July 1, 1943, the Office of War Utilities must report requirements of water utilities for material and equipment for construction of facilities for the period to the end of 1944. You can be helpful by making applications at once for essential projects you will require during this period. If full information is not yet available, you should write a letter to the Water Division giving a brief outline of the type of project under consideration, an estimate of the dollar value of material

and equipment required and, if possible, a schedule for deliveries.

In the case of any construction work which should be considered maintenance or repair but cannot be carried out because of restrictions in Order U–1, water utilities may file a letter application for relief from specific provisions of the Order [*see* p. 981]. In such cases, full details concerning the project, including the dollar value of material involved, should be addressed to Office of War Utilities, War Production Board, Washington, D.C., Ref: U–1.

Your continued co-operation in this war program is appreciated.

Very truly yours,
(signed)
J. A. KRUG, *Director*
Office of War Utilities

EDITORIAL NOTE

The above letter is of great significance to all water works executives. It is highly important to the continued functioning of America's water utilities and to the progress of war production that you file with the Office of War Utilities, just as soon as is practicable, a complete description of the extensions which you deem vital to the functioning of your system through the end of 1944.

Although the above communication indicates that the Office of War Utilities must file its preliminary report of water utility requirements by July 1, 1943, the request could not have been placed on the desks of water works executives soon enough for them to transmit information to the Office of War Utilities for its consideration before that date. Therefore, you should now proceed as promptly as possible to report your extensions requirements for the next year and a half to the Office of War Utilities.

Application and Extension of Preference Ratings

Priorities Regulation No. 3 Amended

AS of June 4, 1943, the WPB issued an amended form of Priorities Regulation No. 3 entitled "Uniform Method of Application and Extension of Preference Ratings." Paragraph (f)(2) reads in part as follows:

"If any person receives an order for any item on List B, bearing a rating assigned for maintenance, repair or operating supplies (as shown by the symbol MRO or other prescribed identification, or which he otherwise knows to have been assigned for that purpose) he shall not give effect to such a rating, and such rating shall be void."

List B includes 33 groups of items. Under Group 13, "Fire Protective Equipment," are listed *fire hydrants* and indicator posts. This in effect nullifies the provisions of WPB Utilities Order U–1, under which water works place orders for maintenance and repair needs for hydrants, etc., and makes it necessary for manufacturers to suspend action on orders for hydrants and/or indicator posts rated under the terms of U–1 until the situation is clarified. The matter has been brought to the attention of the Administrator of Order U–1 in the Office of War Utilities and he has filed a request for modification of P.R. No. 3 to permit the filling of orders for hydrants placed under the terms of U–1. This situation continues as of July 1. Until the regulation is changed manufacturers may require water utilities to obtain an approved PD–1A application or the recently issued Utilities Application Form WPB–2774.

Form WPB–2774

Form WPB–2774 was introduced to the utilities field by an Administrative Letter, dated May 25, 1943, issued over the signature of J. A. Krug. It reads as follows:

"Effective at once, Application Form WPB–2774, formerly Form UF–30, of which a copy is attached, shall replace Application Forms U–1, PD–1A, PD–200, PD–200B, PD–200C, PD–685 and CMP–4C, but not PD–545 or PD–761, for all requests by utilities for authority to begin construction, for priority assistance and for an allotment of controlled materials for utility construction.

"This form is not to be used for appeals from previous denials or from the restrictions of War Production Board orders unless such appeals involve construction. For example, do not use this form when applying for:

1. Permission to exceed inventory quotas or to establish new quotas for

inventories (Use letter application.)

2. Authority to schedule deliveries or make withdrawals from inventory of materials for maintenance, repair or operating supplies (Use letter application.)

3. Permission to purchase aluminum in its controlled materials forms, for maintenance, repair or operating supplies. (Use letter application.)

"This new form does not replace the following application forms:

1. PD–545, for authority to provide facilities (except communications facilities) to serve individual houses or housing projects

2. PD–761, for relief from the provisions of Order U–2 to permit the construction or installation of communication facilities where the proposed construction does not exceed the dollar limitations contained in paragraph (c) (1) (ii) and (c) (1) (iii) of Order U–3.

"Copies of the new form may be secured by writing to this office [Office of War Utilities]. Arrangements have been made to have a supply available in the field offices of the War Prouction Board. Since it is desirable to have all future applications for which it is applicable submitted on the new form, it is urged that you make immediate arrangements to secure a supply. Reproductions of the form may be made by those desiring to do so." [*See* following pages.]

FORM WPB-2774 FORMERLY UF-30 (5-21-43)

UNITED STATES OF AMERICA
WAR PRODUCTION BOARD
OFFICE OF WAR UTILITIES

APPLICATION FOR AUTHORITY TO BEGIN CONSTRUCTION, FOR PRIORITY ASSISTANCE AND FOR ALLOTMENT OF CONTROLLED MATERIALS FOR UTILITY CONSTRUCTION

BUREAU OF THE BUDGET NO. 12-R1136
APPROVAL EXPIRES DECEMBER 5, 1943

FOR WPB USE ONLY

OWU SERIAL NO.

TO: Office of War Utilities
Washington, D. C.

NAME AND ADDRESS OF APPLICANT (Street, City, State)

INSTRUCTIONS - Return *original and two (2) copies* to the War Production Board, Office of War Utilities, Washington, D. C., except that where instructions for PD-200 applications require the filing of utility applications with the PD-200, the utility shall submit this form to the PD-200 applicant. Attach hereto any application which should be filed in connection with this construction in order to request: (1) relief from the restrictions of any order of the War Production Board, (2) approval of a purchase order which requires specific approval from the War Production Board before it can be placed with a manufacturer.

SECTION A

1. BRIEF DESCRIPTION AND LOCATION OF CONSTRUCTION

2. APPLICANT'S REFERENCE NO.

THIS APPLICATION IS:
☐ INITIAL ☐ AMENDMENT ☐ RESUBMISSION

IF RESUBMISSION OF PREVIOUS APPLICATION, GIVE FOR SUCH APPLICATION:
DATE FILED _____ WPB SERIAL NO. _____

3. IDENTIFY BY DATE FILED AND WPB SERIAL NUMBER ANY OTHER APPLICATIONS RELATED TO THIS ONE

4. IN CONNECTION WITH THIS CONSTRUCTION OR ITS PROPOSED USE, IS RELIEF BEING REQUESTED FROM THE RESTRICTIONS OF ANY ORDER OF THE WPB?
a. IN THIS APPLICATION (FOR COMMUNICATIONS ONLY) ☐ YES ☐ NO
ORDER NUMBER _____
b. IN A SEPARATE APPLICATION ATTACHED HERETO ☐ YES ☐ NO
ORDER NUMBER _____
c. IN A SEPARATE APPLICATION PREVIOUSLY SUBMITTED ☐ YES ☐ NO
ORDER NUMBER _____
IF IN A SEPARATE APPLICATION PREVIOUSLY SUBMITTED, GIVE DATE OF APPLICATION _____

5. IF PROPOSED UTILITY CONSTRUCTION IS TO SERVE A CUSTOMER, GIVE STATUS OF CUSTOMER'S CONSTRUCTION, IF ANY, AS FOLLOWS:
☐ NOT STARTED ☐ UNDER CONSTRUCTION ☐ COMPLETED ☐ NO CONSTRUCTION

GIVE STATUS OF CUSTOMER'S APPLICATION FOR PROJECT RATING, IF ANY:
☐ CUSTOMER STATES NOT REQUIRED ☐ SUBMITTED WITH THIS FORM
☐ SUBMITTED PREVIOUSLY DATE _____
WPB SERIAL NUMBER AND PROJECT RATING

6. TYPE OF UTILITY
☐ ELECTRIC ☐ WATER
☐ NATURAL GAS ☐ MFD. GAS
☐ STEAM HEATING ☐ COMMUNICATIONS

7. FOR COMMUNICATIONS CONSTRUCTION, NAME AND ADDRESS OF PROBABLE SUPPLIER(S)

8. DATE UTILITY CONSTRUCTION STARTED OR IS SCHEDULED TO START

DATE SCHEDULED FOR COMPLETION

PERCENT COMPLETED %

9. ESTIMATED TOTAL COST OF UTILITY CONSTRUCTION

ITEM	AMOUNT
MATERIAL	
LABOR	
OTHER COSTS	
TOTAL	

SECTION B - DESCRIPTION OF AND NECESSITY FOR CONSTRUCTION

Furnish the following information, referring to the numbers of the following paragraphs:

1. A detailed description of proposed construction or equipment, together with reasons for type, size and quantity or capacity of facilities to be provided.
2. A statement of the relationship of the proposed construction to existing facilities; show why existing facilities are inadequate and consequences if proposed facilities are not built.
3. A detailed explanation of the necessity for the proposed construction, including a statement of its relationship to military needs, war production, or essential civilian needs.
4. If application is for construction to serve a customer, a description of the customer's plant, project or other property to be served and, where pertinent, quantitative data as to customer's present and estimated future requirements for utility service of the type covered by this application.
5. A statement explaining whether service can be rendered in any other way, or by any other producer or operator, with the use of smaller quantities of critical materials.
6. If extensions or additions to outside plant are involved, a sketch showing the details of the proposed constructions and its relation to existing facilities.
7. A list identifying each exhibit or document attached.

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FORM WPB-2774 FORMERLY UF-30 (5-21-43) PAGE 2 OF 4 PAGES

SECTION B Continued

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SECTION C - MATERIAL REQUIREMENTS

Do not type single spaced in Columns b to h inclusive

DESCRIPTION OF MAJOR ITEMS OF MATERIALS (Indicate type, size and unit) GROUP MINOR ITEMS (a)	TOTAL MATERIAL REQUIRED FOR CONSTRUCTION: NO. OF UNITS (b)	DOLLAR VALUE (c)	FOR WPB USE ONLY (d)	MATERIAL ON WHICH RATING IS REQUESTED[1]: REQ'D. DEL. DATE (Month) (e)	NO. OF UNITS[2] (f)	DOLLAR VALUE (g)	FOR WPB USE ONLY (h)
TOTAL	XXX			XXX	XXX		

[1] *Rating should be requested on all material which must be purchased with the use of a preference rating, including material to be used from minimum inventory which is to be replaced. Rating should not be requested for material available from your excess stocks, or expected to be obtained from excess stocks of other utilities.*

[2] *Indicate the items for which allotment is requested in Section D, by placing an X after each such item in Column (f).*

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FORM WPB-2774 FORMERLY UF-30 (5-21-43) PAGE 4 OF 4 PAGES

SECTION D - ALLOTMENT OF CONTROLLED MATERIALS

Show below the quantities of controlled materials which must be shipped each quarter to you or your contractors, and to your secondary consumers for the manufacture of Class A products, in order that you may meet the tentative schedule for this construction as shown in Item 8, Section A. Do not include amounts of controlled materials to be withdrawn from inventory not to be replaced or amounts to be obtained from another utility, nor controlled materials required for the manufacture of Class B products to be incorporated in this construction. *IMPORTANT: Specify Quarters)*

CONTROLLED MATERIALS (a)	QUARTER 19__ REQUIRED (b)	QUARTER 19__ ALLOTTED (Lv. Blank) (c)	QUARTER 19__ REQUIRED (d)	QUARTER 19__ ALLOTTED (Lv. Blank) (e)	QUARTER 19__ REQUIRED (f)	QUARTER 19__ ALLOTTED (Lv. Blank) (g)	QUARTER 19__ REQUIRED (h)	QUARTER 19__ ALLOTTED (Lv. Blank) (i)
STEEL (*Tons - 2000 Lbs*) 1. CARBON (2001-2061)								
2. ALLOY (2501-2561)								
COPPER-BASE ALLOY (*Lbs.*) 3. SHEET & STRIP (3011)								
4. RODS, BARS & WIRE (3021)								
5. TUBING & PIPE (3041)								
COPPER PRODUCTS (*Lbs.*) 6. BRASS MILL (3051-71)								
7. WIRE MILL (3101)								
COPPER & CU-BASE ALLOY (*Lbs.*) 8. CASTINGS (3201)								
ALUMINUM (*Lbs.*) 9. CASTINGS (4202-4218)								
10. IF OTHER, SPECIFY FORMS OR SHAPES								

CERTIFICATION - THE UNDERSIGNED HEREBY CERTIFIES THAT HE IS THE APPLICANT OR THAT HE IS AUTHORIZED TO EXECUTE THIS APPLICATION ON BEHALF OF THE APPLICANT; THE QUANTITIES AND REQUIRED DELIVERY DATE(S) SPECIFIED ARE NOT GREATER NOR EARLIER THAN NECESSARY FOR COMPLETION ON TIME OF THIS CONSTRUCTION, THE FACTS HEREIN SET FORTH, OR APPENDED ARE TRUE AND CORRECT TO THE BEST OF HIS KNOWLEDGE AND BELIEF

DATE _____ BY _____ SIGNATURE AND TITLE OF AUTHORIZED OFFICIAL

SECTION 35(A) OF THE UNITED STATES CRIMINAL CODE, 18 U.S.C. SEC. 80, MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

SECTION E - FOR WPB USE ONLY

AUTHORIZATION OF CONSTRUCTION, ASSIGNMENT OF PREFERENCE RATING AND ALLOTMENT NUMBER, AND ALLOTMENT OF CONTROLLED MATERIAL

1. The applicant is hereby authorized to proceed with the construction or installation described herein, subject to all applicable orders and regulations of the War Production Board and to any exceptions or restrictions noted below.

2. An allotment of controlled materials is hereby made in the kinds and quantities and for the quarters set forth in Section D, Columns b,d,f, and h as modified by any amendments appearing in Columns c,e,g, and i. The allotment number

☐☐☐☐ ☐☐☐

is hereby assigned for the procurement of those materials only.

3. The applicant is hereby authorized to purchase from other producers or operators the material set forth in Section C, Columns b and c as modified by any amendments appearing in Columns b and d, without the use of a preference rating or allotment number subject to any exceptions or restrictions noted below. The authorization, in the case of producers under Utilities Order U-1, constitutes a "specific direction" for the purposes of paragraph (i) of that Order, and in the case of operators under Utilities Orders U-3, U-4 and U-5, constitutes an exemption for the purposes of paragraph (b) (3) of Order U-5 and related provisions of Orders U-3 and U-4. Producers or operators with whom orders are placed should be so advised.

4. The preference rating noted below is hereby assigned to deliveries of only those materials set forth in Section C in the amounts noted in Columns f and g, as modified by any amendments appearing in Columns f and h, subject to any exceptions or restrictions noted below. This rating may not be applied to a delivery of material which can be obtained from the applicant's inventory in excess of a practical working minimum.

5. Exceptions:

_____ SIGNATURE

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Applications for Relief From U–1 Restrictions

WATER utilities (hereinafter termed "Producers") submitting applications for relief from the restrictions of Paragraph (f) of WPB Utilities Order U–1 on inventories, withdrawals and deliveries in some cases fail to provide sufficient information to permit determination of the justification for the requested relief. Permission to exceed the U–1 restrictions on inventories, deliveries and withdrawals should not be requested by producers except when their circumstances are such as to make it impossible to safeguard the supply of utility service under wartime conditions without such relief. Critical material shortages still continue and no Producer should request authority to maintain larger inventories or use larger quantities of materials than are absolutely necessary. Where circumstances are such that the Producer finds it necessary to request relief from the restrictions of the order, the following information should be supplied:

1. *Inventory:* In requesting permission to establish specific practical working minimum inventories in excess of those permitted by U–1, the Producer should state, by control class totals only, the dollar value of his 1940 inventory, the inventory permitted by U–1 and the inventory required for his present essential needs. The Producer should explain the reason why it is necessary to request higher inventory bases than are authorized by U–1. This explanation should cover the amount of plant for which his inventory furnishes protection, the relationship of plant values and essential inventory, the amount of inventory classified as spare parts, the past turnover of inventory classes and all other pertinent factors. This study should cover only major items of material and those which aggregate relatively large amounts.

2. *Deliveries and Withdrawals for Maintenance, Repairs and Operations:* If, because of unusually low use of materials in the last months of 1942, a Producer considers it necessary to establish a higher base for deliveries and withdrawals under U–1, he should state in his request, by control class totals, the dollar value of his withdrawals in 1940, the withdrawal base as determined by U–1 and the base necessary for his essential needs. The Producer should state briefly his reason for requesting an increase in base. If it is necessary to exceed the withdrawal or delivery restrictions of U–1 for an unusual maintenance or repair job, the Producer should submit a request for permission to accept deliv-

An unofficial (but reliable) statement concerning the procedure to follow in obtaining relief from the restrictions of WPB Utilities Order U–1.

eries and make withdrawals during a specific calendar quarter, or quarters, stating, by control class totals, his normal delivery and withdrawal base, the dollar amount of deliveries and withdrawals necessary for the unusual job, that part of the unusual deliveries and withdrawals which can be absorbed in his normal bases and the dollar amounts by which it is necessary to exceed his normal deliveries and withdrawals. Producers should not request permission to exceed the delivery and withdrawal restrictions of U–1 simply because the maintenance or repair job is unusual or emergency. They should accomplish this work, if at all possible, within their normal delivery or withdrawal bases and ask for permission to exceed by only the amounts necessary to meet their essential needs.

3. *Deliveries and Withdrawals for Extension to Consumers Under U–1–c, U–1–d and U–1–e:* If it is not possible for a Producer to make extensions authorized by U–1–c, U–1–d and U–1–e within the normal deliveries and withdrawals authorized by U–1, he should submit a request for permission to exceed the delivery and withdrawal restrictions of U–1 for a specific calendar quarter or quarters, indicating by control class totals only, for each quarter, the normal delivery and withdrawal base, the estimated dollar value of withdrawals necessary to make such extensions, that part of the withdrawals which can be made within the normal authorization of U–1 and that part of the withdrawals which must be made in excess of the restrictions of U–1. He should also state that part of the necessary deliveries which can be made from his excess inventory and that part which must be purchased from other Producers or Suppliers. The Producer should indicate briefly the number and type of consumers which are to be connected.

All deliveries and withdrawals which are authorized in excess of the restrictions of U–1 are to be considered as deliveries and withdrawals under U–1 and included in the Producer's record of deliveries and withdrawals under U–1, including reports which are required from Producers under U–1. Producers should indicate in their records under U–1, and in filing quarterly reports when required by the War Production Board, all specific authorizations to exceed the restrictions of U–1